Event-Based Visualization for User-Centered Visual Analysis

Christian Tominski
University of Rostock
November 8th, 2006
Classic vs. Event-Based Visualization

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Outline

• Motivation
• Related work
• Classification schema for event-based visualization
• General model for event-based visualization
  1. Event specification
  2. Event detection
  3. Event representation
• Applications
Motivation

• Challenges:
  – Large data sets lead to cluttered and overcrowded visualizations
  – “Gap between what is being shown (…) and what actually needs to be shown (…)” (Amar & Stasko, 2005)
  – Different users and different data aspects require flexible visualizations

• Goal: Effective, relevant, and flexible visualization
Related Work

Events used in a variety of ways with a variety of meanings:

- Modeling and Simulation
- Knowledge Discovery
- Artificial Intelligence
- Software Engineering
- Databases
- ...
Related Work

- Reinders et al., 2001
- Matković et al., 2002
- Erbacher et al., 2002
- Kranzmüller, 2002
- Coupaye et al., 1999
- Chittaro et al., 2003
## Classification Scheme

<table>
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<th>Event Complexity</th>
<th>Simple Events</th>
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Event-Based Visualization

1. Users specify interests as event types
2. Detect actual occurrences of events
3. Create visual representations that highlight events

Getting the user involved!
Formal Event Definition

- Event domain
  - Entity
  - Event domain: $ED$
  - Entity domain: $ed$

- Event types
  - Abstract event type
    - (event types compatible with $ED$)
  - Event types: $ET$
  - Event type: $et$

- Event parameters
  - Event instance: $E$

- What can be of interest?
- What makes an entity interesting?
- Which entity is interesting?
New General Model

1. Event Specification → Event Types
2. Event Detection → Event Instances
3. Event Representation → Actions / Processes

Raw Data → Event Data → Visualization

Data Analysis → Filtering → Mapping → Rendering → Image Data

Explicit
Implicit
Event Specification

Challenge: Bridge gap between computer (formal machine) and user (informal interests)

• Formal description: **Event formulas** based on PL
  – Data model: Relational data
  – Syntax: Variables as placeholders for entities, predicates, functions, aggregates, logical connectors, quantifiers

• Event types:
  – Tuple and attribute event types (based on PL)
  – Sequence event types (based on (Sadri et al., 2004))
  – Composite event types (based on set theory)
Event Specification

User-centered event specification

Event formula

Direct specification

Event type template

Parametrization

Event type collection

Selection

User

Specification efforts

high

low
Event Specification

Visual event specification

• **Brushing:**
  – Direct interaction with visualization
  – Limited to scope of data set

• **Visual editor:**
  – Visual interface to abstract formalism
  – Arbitrary event types
  – Limited by “Deutsch Limit”

Hauser et al., 2002
Event Detection

- Task: Find actual event instances
- Realization: Variable substitution, formula evaluation
- **Event instance**: \( e = (\text{entity, event type, parameters}) \)

Detection process:
- **Static data**
  - Events detected in preprocess prior to visualization
- **Dynamic data**
  - Detect events whenever data changes
  - Detection efficiency becomes an issue
Event Detection

Improving event detection efficiency

• Database technology:
  – Map event formulas to SQL queries
  – Apply algorithms with proved efficiency (e.g., (Sadri et al., 2004))
  – Incremental detection methods

• User-centered event detection:
  – Narrow search space: Users less/not interested in “old” events
  – Heavily dependent on application context
Event Representation

• Task: Guide attention to interesting parts of visual representation

• Requirements:
  – Communicate the fact that something interesting has occurred
  – Emphasize on event instances in visual representation
  – Convey the types of occurred events
Implicit Event Representation

- **Goal:** Adaptation of known visualization techniques
- **Challenge:** Find suitable parameters to adapt
- **Principle:** Actions (instantaneous) or processes (gradual) realize parameter changes
  - Data analysis: Clustering, smoothing, ...
  - Filtering: Selection, projection, neighbors, ...
  - Mapping: Geometry, attributes (e.g., color), layout
  - Rendering: Viewpoints, depth of field, importance-driven rendering
- **Effect:** Local vs. global changes in visualization
Explicit Event Representation

• Goal: Visualize events, rather than data
• Challenge: Find expressive event attributes
  – Event type (categorical value)
  – Time, space, ...
• Principle:
  – Map events and their attributes to new relational data set
  – Use dedicated techniques to represent event data (e.g. space-time-paths)
eVis Framework

1. Data Import
   - Data Interface
     - CSV File
     - SQL Query Result
     - ...
   - Raw Data

2. Management
   - Data
     - Event Types
   - Users

3. Graphical User Interface
   - Event Specification
     - Event Type Interface
       - XML Schemas
       - Visual Editor
     - ...

4. Event Detection
   - Event Instances

5. Event-Based Visualization
   - Visualization Interface
     - TableLens
     - VisAxes
     - TimeMap
     - ...

6. Interests

7. Data Flow
   - Event-related flow
   - User control flow
Event Integration in VisAxes

- **No events considered**
- **Events automatically emphasized**

[Visualization diagrams showing various techniques such as Influenza, Rotation, Brushing, and Focusing]
Events in Time and Space
Events and Graph Visualization

- Specify event types via filter interface
- Focus on interesting nodes via lenses
Results

- Classification scheme for event-based visualization

- **New general model for event-based visualization**, including event specification, event detection, and event representation

- Proof of concept:
  - Events for relational data model
  - Extensible framework for event-based visualization
  - Application of event-based concepts to graph visualization
Results

Event-based visualization can help to generate effective, relevant, and flexible visualizations that shift the interests of users into the focus!
Future Work

• Event specification
  – Further and improved event types
  – Enhance event specification

• Event detection
  – User-centered event detection
  – Incremental methods
  – Special kinds of data (e.g., data streams)
Future Work

• Event representation:
  – Analyze perceptual issues
  – Conduct user studies
  – Make event representation as flexible as event specification

• Further aspects:
  – SVG/X3D and Active Databases
  – Mobile devices
Thank you!
Event-Enhanced TableLens

No events considered

The latest event is automatically focused
Interpretation of Event Instances

Attribute event, tuple event, and sequence event occurred in a relational dataset.

Attribute event interpretation

Tuple event interpretations

Sequence event interpretations

(a) $A_1$ $A_2$ $A_3$

(b) $A_1$ $A_2$ $A_3$

(c) $A_1$ $A_2$ $A_3$

(d) $A_1$ $A_2$ $A_3$

(e) $A_1$ $A_2$ $A_3$

(f) $A_1$ $A_2$ $A_3$
Predicates for Event Specification

- $eq(x, y)$
- $po(x, y)$
- $ec(x, y)$
- $dc(x, y)$
- $tpp(x, y)$
- $ntpp(x, y)$
- $tppi(x, y)$
- $ntppi(x, y)$

- $equals(x, y)$
- $before(x, y)$
- $during(x, y)$
- $meets(x, y)$
- $starts(x, y)$
- $finishes(x, y)$
Event Formula

\[ \{ \dot{x} | \dot{x}.\text{AvgTemp} < 0 \} \]

```
SELECT *
FROM data
WHERE AvgTemp < 0
```