DYNAMIC CARTOGRAPHY: MAP-ANIMATION CONCEPTS FOR POINT FEATURES
I. motivation and aim
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- In our field we deal with classical objects and processes that characterize natural environment.

- Data collection of natural objects
  - Is performed in GIS
  - Primarily based on comparable interpretation of remote sensing data and analysis of digital terrain models

- All natural objects
  - Are linked by complex relationships and constraints.
  - Have at least 3 temporal information: start-, end point and $\Delta t$
TIME itself represents an attribute that is directly attached to the individual object and its other attribute data.

but TIME however,

- is previously documented very inadequate in GIS and mostly resolved on an external timeline.

The question is:

Q1 How the temporal aspect of natural objects could be stored and visualized efficiently?
I. motivation and aim

- concept for GIS-based data structure to accommodate, access, analyze, and visualize time-dependent objects.

- integrate the TIME (in form of dimension, duration, start/end) directly via the underlying data model!

- geometry + topical attribute + time + graph. attribute

Q2 Could this concept be implemented as a temporal animation based on GIS technologies (e.g. within a dynamic and web-based mapping service)?
II. concept
II. concept

concept based on point symbols with fixed spatial coordinates, because they represent the lowest level in geometry and topology but provided the highest level of abstraction!

⇒ That implies, if lowest level of geometry can modelled in time any higher-level or derived object can be modelled equally well.
II. Concept

time-dependent changes and their graphical variables

<table>
<thead>
<tr>
<th>possible changes of object</th>
<th>scaling level</th>
<th>possible variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>composition</td>
<td>qualitative and quantitative</td>
<td>color / brightness</td>
</tr>
<tr>
<td>size</td>
<td>quantitative</td>
<td>size</td>
</tr>
<tr>
<td>depending on (t) → increasing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>direction</td>
<td>quantitative</td>
<td>rotation / direction</td>
</tr>
<tr>
<td>depending on (t) → velocity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **object changes**, and thus symbol changes, may appear **alone but also in combination**
II. Concept

- Size
- Rotation
- Color
II. concept
II. concept
II. Concept

- 0-dimensional signature
- 1-dimensional signature
- 2-dimensional signature
- 3-dimensional signature
objects + processes and their **temporal reference**

- **temporal range**: $t_n - t_i$
- **temporal process**: $t_{i+1} - t_i$
- **temporal events**: $t_i$

- 2 types of (condition) change by objects + processes
  - **to** an amount: always positive and absolutely $\in \mathbb{R}^+$
  - **by** an amount: can be positive or negative, as well as absolute and relative $\in \mathbb{R}$
II. concept
II. concept

t1 | S1 | C1 | R1

timeline 16.06.2014
II. concept

<table>
<thead>
<tr>
<th>t1</th>
<th>S1</th>
<th>C1</th>
<th>R1</th>
</tr>
</thead>
<tbody>
<tr>
<td>t2</td>
<td>S2</td>
<td>C2</td>
<td>R2</td>
</tr>
</tbody>
</table>

timeline: 16.06.2014 to 10.07.2014
II. concept

<table>
<thead>
<tr>
<th>t1</th>
<th>S1</th>
<th>C1</th>
<th>R1</th>
</tr>
</thead>
<tbody>
<tr>
<td>t2</td>
<td>-S2</td>
<td>-C2</td>
<td>-R2</td>
</tr>
</tbody>
</table>

timeline

16.06.2014

10.07.2014
II. concept

t1 | S1 | C1 | R1

16.06.2014

t2 | -S2 | C2 | -R2

10.07.2014

timeline
III. changes of symbols
III. changes of symbols

changing color or brightness

- bipolar or multipolar or brightness?
- CMYK, RGB, HSI etc.

- range of values
  - to an amount \( \rightarrow \) \( c_i = \{ n \in \{ \text{RGB} \mid \text{HSI} \mid \text{CMYK} \} \} \)
  - by an amount \( \rightarrow \) \( c_i = \{ \Delta \text{RGB} \mid \Delta \text{HSI} \mid \Delta \text{CMYK} \} \)

- examples
  - classes of risk (not continuous but discrete classes)
  - resizing of masses (continuous!)
III. changes of symbols

changing size

- percentage or absolute?

- range of values
  - to an amount $\rightarrow s_i = \{n \in R^+, O \ldots n\}$
  - by an amount $\rightarrow s_i = \{n \in R, -n \ldots O \ldots n\}$

- examples
  - enhancement of land slide
  - flooded land by tsunami
III. changes of symbols

changing direction or rotation

- start-/+ end angle OR 360° with constant velocity

- range of values
  - to an amount $\varphi_i = \{n \in R^+, O \ldots n\}$
  - by an amount $\varphi_i = \{n \in R, -n \ldots O \ldots n\}$

- examples
  - land slides with a velocity $x$ downhill
  - rock measurement
IV. map example

thematic 3-dimensional point symbol

land slide mapped by mass (size), direction (rotation) and classes of risk (color).

symbol rotation demonstrates the direction of land slide
IV. implementation in object tables
### IV. implementation in object tables

<table>
<thead>
<tr>
<th>object</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Id</td>
<td>int</td>
</tr>
<tr>
<td>geometry</td>
<td>point</td>
</tr>
<tr>
<td>y_koord</td>
<td>float</td>
</tr>
<tr>
<td>x_koord</td>
<td>float</td>
</tr>
<tr>
<td>time</td>
<td>timestamp</td>
</tr>
<tr>
<td>value_1</td>
<td>{int, float, char}</td>
</tr>
<tr>
<td>c_a (FK)</td>
<td>int</td>
</tr>
<tr>
<td>c_r (FK)</td>
<td>int</td>
</tr>
<tr>
<td>value_2</td>
<td>{int, float, char}</td>
</tr>
<tr>
<td>s_a</td>
<td>float</td>
</tr>
<tr>
<td>s_r</td>
<td>float</td>
</tr>
<tr>
<td>value_3</td>
<td>{int, float, char}</td>
</tr>
<tr>
<td>r_a</td>
<td>float</td>
</tr>
<tr>
<td>r_c</td>
<td>float</td>
</tr>
</tbody>
</table>
IV. implementation in object tables

- **object**
  - object_id (int)
  - geometry (point)
  - y_koord (float)
  - x_koord (float)

- **time**
  - time_id (int)
  - object_id (FK)
  - time (timestamp)

- **value**
  - value_id (int)
  - value_type (int)

- **t_v_c**
  - time_id (FK)
  - value_id (FK)
  - colour_id (FK)

- **colour**
  - colour_id (int)
  - colour (timestamp)

- **t_v_s**
  - time_id (FK)
  - value_id (FK)
  - size_id (FK)

- **size**
  - size_id (int)
  - size (float)

- **t_v_r**
  - time_id (FK)
  - value_id (FK)
  - rotate_id (FK)

- **rotation**
  - rotate_id (int)
  - rotation (Float)
V. conclusion and open questions
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Q1 How the temporal aspect of natural objects could be stored and visualized efficiently?
V. conclusion and open questions

Q1 How the temporal aspect of natural objects could be stored and visualized efficiently?

- through the time-based signature-cube all possible visualization combinations of point features could be illustrated.

That serves as basis concept for a ......

- GIS-based data structure that directly integrates and cartographically animates the temporal character of natural objects within an underlying data model.
Q2 Could this concept be implemented as a temporal animation based on GIS technologies?
Q2 Could this concept be implemented as a temporal animation based on GIS technologies?

- possibilities for animation via moving paths? current solution based on illustration of instances (via single frames)!

- concrete storage of values for color-, size- and rotation symbol variation?

- implement graphical information directly into the data model e.g. by *.svg-script?

- connection to a dynamic and web-based mapping service?
THANK YOU FOR YOUR ATTENTION!

QUESTIONS?

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