Querying GIS with Animated Spatial Sketches

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Motivation

Query Spatial Databases (GIS)

- Sketch constellation of spatial objects
  - Topological and geometric relationships between components are important
- Consider relationships in sketches as query constraints
- Interpret sketch as “sentence” of a visual query language

Explicit Meta Information

- Relaxation of geometrical (topological) constraints needed
- Derived constraints (e.g. centered)
Naive Physics Metaphor

Semantics of Query Objects

Physical properties visualize semantics
- **0-D**: marbles, nails, swivel joints
  - e.g. marble: roll around, change position
- **1-D**: (cross) beams, rubber bands, telescoping antenna
  - e.g. rubber band: stretch, shrink, wrap around
- **2-D**: enclosures, transparencies
  - e.g. enclosure: fenced area trapping marbles

Animation
- Degrees of freedom gained by relaxations
- Variations of user sketches visualized by animations
VISCO’s Language Elements

- Fixpoint
- Marble
- Nail
- Beam
- (Atomic) Rubber Band
- Crossbeams
  - Fixed Angle
  - Minimal Angle
  - Maximal Angle
  - Min + Max Angle
- Parallelogram as example

- Compass
- Enclosure
- Polygon
- Transparency Film

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VISCO: Transparency Films

Basic Building Block

- Transparency film (of an overhead projector)
  - Rectangular shape
  - Own local cartesian coordinate system
  - Can be scaled, translated, rotated, and stacked up
  - Fixpoint (w.r.t. transformations) is required
    - Any nail (isolated or as vertex) on transparency
- Users interactively draw VISCO's query elements
- Collection of drawn elements defines (sub)constellation
  - Geometrical and topological relationships are relevant

- One transparency as drawing sheet
- Two transparencies each with objects

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Example: Various Quadrilaterals

- matches at most 4 line segments
- marbles act as swivel joints and may float inside of enclosure
- rubber bands may stretch or shrink

- 4 beams as edges
  - marbles act as swivel joints and may float inside of enclosure
  - beams have a fixed length

- 4 beams as edges
  - marbles may float inside of enclosure
  - beams have a fixed length and a fixed right angle
  - fixed orientation
### Enclosure

- Enclosure is meta object
  - visualized by a gray texture
  - all enclosed objects are "trapped" and must stay inside of their enclosure
- Two types of enclosures
  - **translucent**: also consider relationships with other visible objects
  - **opaque**: hidden objects are excluded
- Computed $\varepsilon$-enclosures
  - interior or exterior (border) of an object
  - radius is required

### Point

- Semantics of nails not affected
- Marbles are only allowed inside of enclosures
- Marbles may freely change their position
Example: Rectangle Touching Scalable Circle
City Map Example: Öjendorf as Subsection of Hamburg

- Areas intended as query matches are marked
- Input for query processing is a vector representation of this map

Map data donated by the 'Amt für Geoinformation und Vermessung'
City Map Example: Church in vicinity of subway station

Snapshots of query construction with example of intended match

- Create transparency of fixed size (300 x 300 m)
- Draw a fixpoint (nail) and attach the concept 'SubwayStation' to fixpoint
  - fixpoint may coincide with any point object in database
- Generate circular $\varepsilon$-enclosure
  - fixpoint as center
  - radius of 100 m
- Draw a marble inside of the enclosure and attach the concept 'Church' to marble
City Map Example: 3 adjacent buildings aligned in parallel (1)

Create scalable, rotatable transparency with enclosure

Sketch three quadrilaterals
City Map Example: 3 adjacent buildings aligned in parallel (2)

Constrain orientation of edges as visualized

Generate center points of quadrilaterals (marbles)
City Map Example: 3 adjacent buildings aligned in parallel (3)

Example of intended match

Draw enclosure confining center points more closely
Conclusion and Ongoing Research

- VISCO is innovative compared to other relevant approaches (see related work in paper)
  - geometric as well as topological queries or combination of both
  - high expressiveness by interpreting topological relations as qualitative constraints enriched with meta information
  - simple but powerful 'naive physics' metaphor
  - approximate or vague objects/constellations possible
- Prototype implementation partially completed (user interface)
- Query semantics specified by translational semantics (typed lambda calculus)
- Description logic framework for query processing and optimization is under development