# Qualitative Spatial Reasoning over Line-Region Relations

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Knowledge Representation
Seminar Presentation

# Agenda

**Motivation**

**Background**
- Lines and Regions
- Topological Parts of an Object
- 9-Intersection

**Conceptual Neighborhood Models**
- Snapshot Model
- Smooth Transitions

**Evaluation**

**Conclusion**

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# Smooth Transitions

## Conceptual Neighborhood

A line-region relation is topologically different from another one by an infinitesimally small deformation of its geometry.

## Possible Changes

A total of four rules:

- Moving around a line's boundary nodes

**Rule 1** Line's two boundary nodes intersect with same region part
**Rule 2** Line's two boundary nodes intersect with different region part

- Moving around a line's interior

**Rule 3** Extend line's interior-intersection partially
**Rule 4** Reduce line's interior-intersection partially

In terms of 9-Intersection, a smooth transition means that an intersection or its adjacent intersection gets changed from empty to non-empty, or reverse.

# Extent of a Line Part

Extent of a part $i$: Denoted by $\#M[i, \_]$; number of non-empty intersections between $i$ and th three parts of the second object. Define extent of a part i Draw 9-intersection model on the board for reference

- The extent of a line's interior with respect to a region is in the interval of 1 to 3, the extent of the lines boundary is either 1 (if both nodes are located in the same region part) or 2 (if the nodes are located in different parts of the region), and the extent of a line's interior is always 3.

# Moving the Line's Boundaries

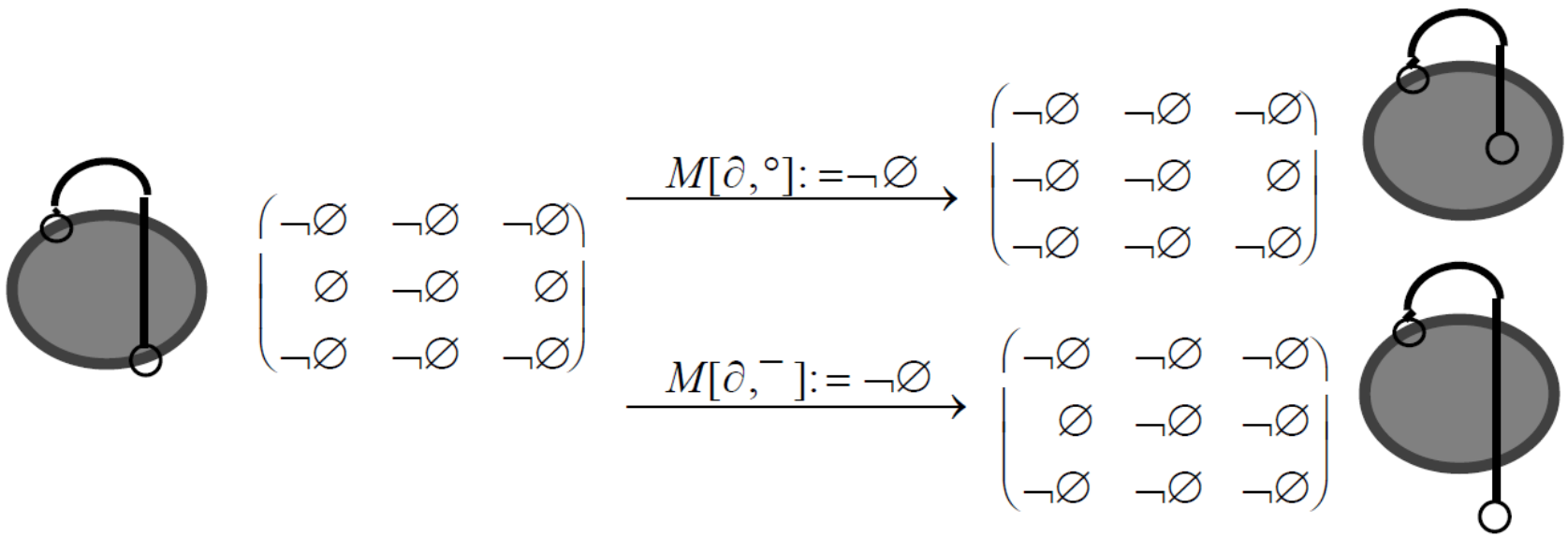
## Rule 1

If the line's two boundaries intersect with the same region part, then extend the intersection to either of the adjacent region parts.

## Formalization

$$\#M[\delta, \_] = 1 \Rightarrow \forall i(M[\delta, i] = \neg\varnothing) : M_N[\delta, \text{adjacent}(i)] := \neg\varnothing$$

## Example



# Moving the Line's Boundaries

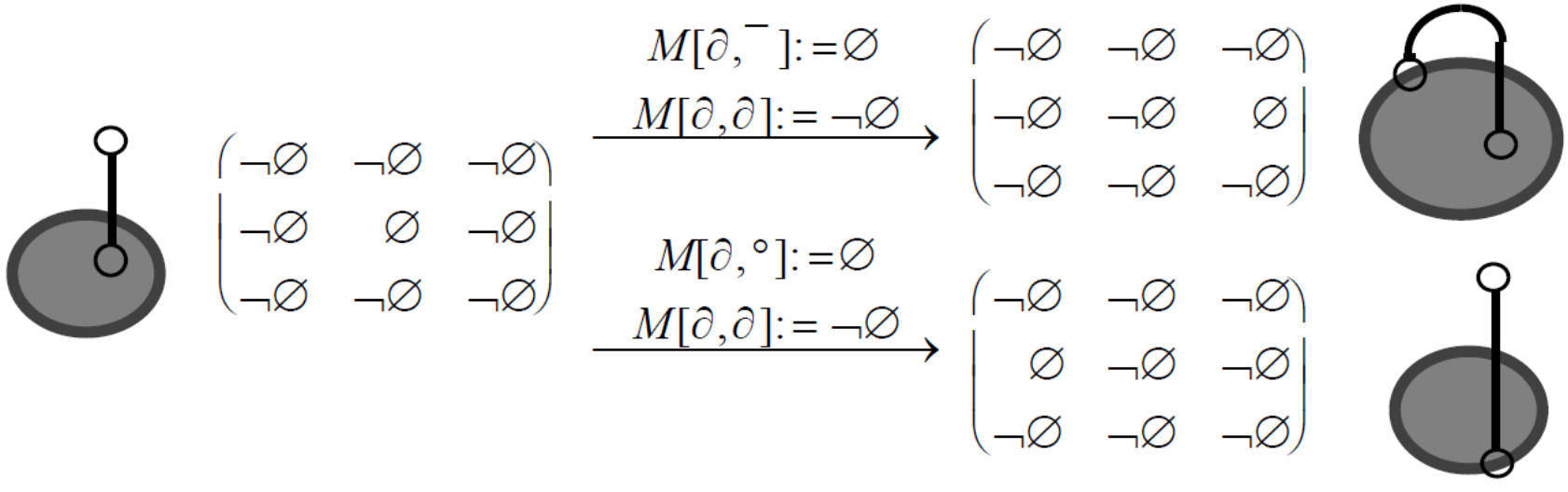
## Rule 2

If the line's two boundaries intersect with two different region parts then move either intersection to the adjacent region part.

## Formalization

$$\#M[\delta, \_] = 2 \Rightarrow \forall i(M[\delta, i] = \neg\varnothing) : M_N[\delta, i] := \varnothing \textbf{ and } M_N[\delta, \text{adjacent}(i)] := \neg\varnothing$$

## Example



# Moving the Line's Interior

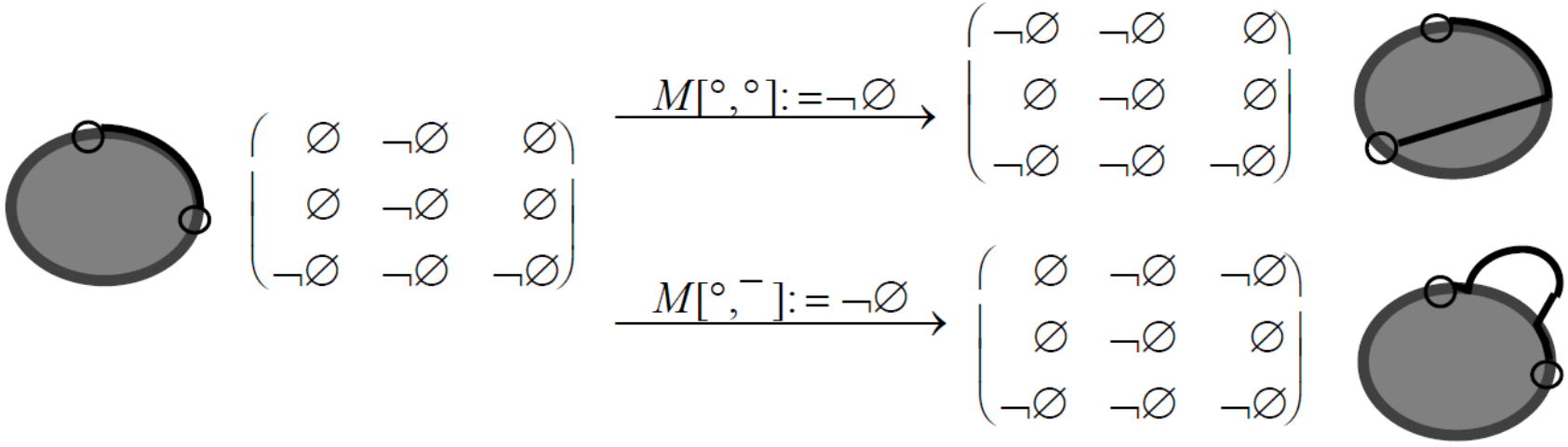
## Rule 1

Extend the line's interior-intersection to either of the adjacent region parts.

## Formalization

$$\forall i(M[^\circ, i] = \neg\varnothing) : M_N[^\circ, \mathsf{adjacent}(i)] := \neg\varnothing$$

## Example



# Moving the Line's Interior

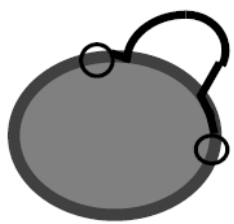
## Rule 2

Reduce the line's interior intersection on either of the adjacent region parts.

## Formalization

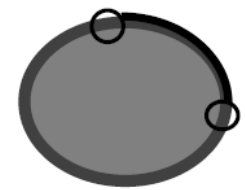
$$\#M[^\circ, \_] = 2 \Rightarrow \forall i(M[^\circ, i] = \neg\varnothing) : M_N[^\circ, i] := \varnothing$$
$$\#M[^\circ, \_] = 3 \Rightarrow \forall i(i \neq \delta) : M_N[^\circ, i] := \varnothing$$

## Example

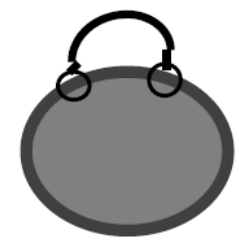


$$\begin{pmatrix} \varnothing & \neg\varnothing & \neg\varnothing \\ \varnothing & \neg\varnothing & \varnothing \\ \neg\varnothing & \neg\varnothing & \neg\varnothing \end{pmatrix}$$

$$\xrightarrow{M[^\circ,\partial] := \varnothing} \begin{pmatrix} \varnothing & \neg\varnothing & \varnothing \\ \varnothing & \neg\varnothing & \varnothing \\ \neg\varnothing & \neg\varnothing & \neg\varnothing \end{pmatrix}$$



$$\xrightarrow{M[^\circ,^-] := \neg\varnothing} \begin{pmatrix} \varnothing & \varnothing & \neg\varnothing \\ \varnothing & \neg\varnothing & \varnothing \\ \neg\varnothing & \neg\varnothing & \neg\varnothing \end{pmatrix}$$



# Consistency Constraints

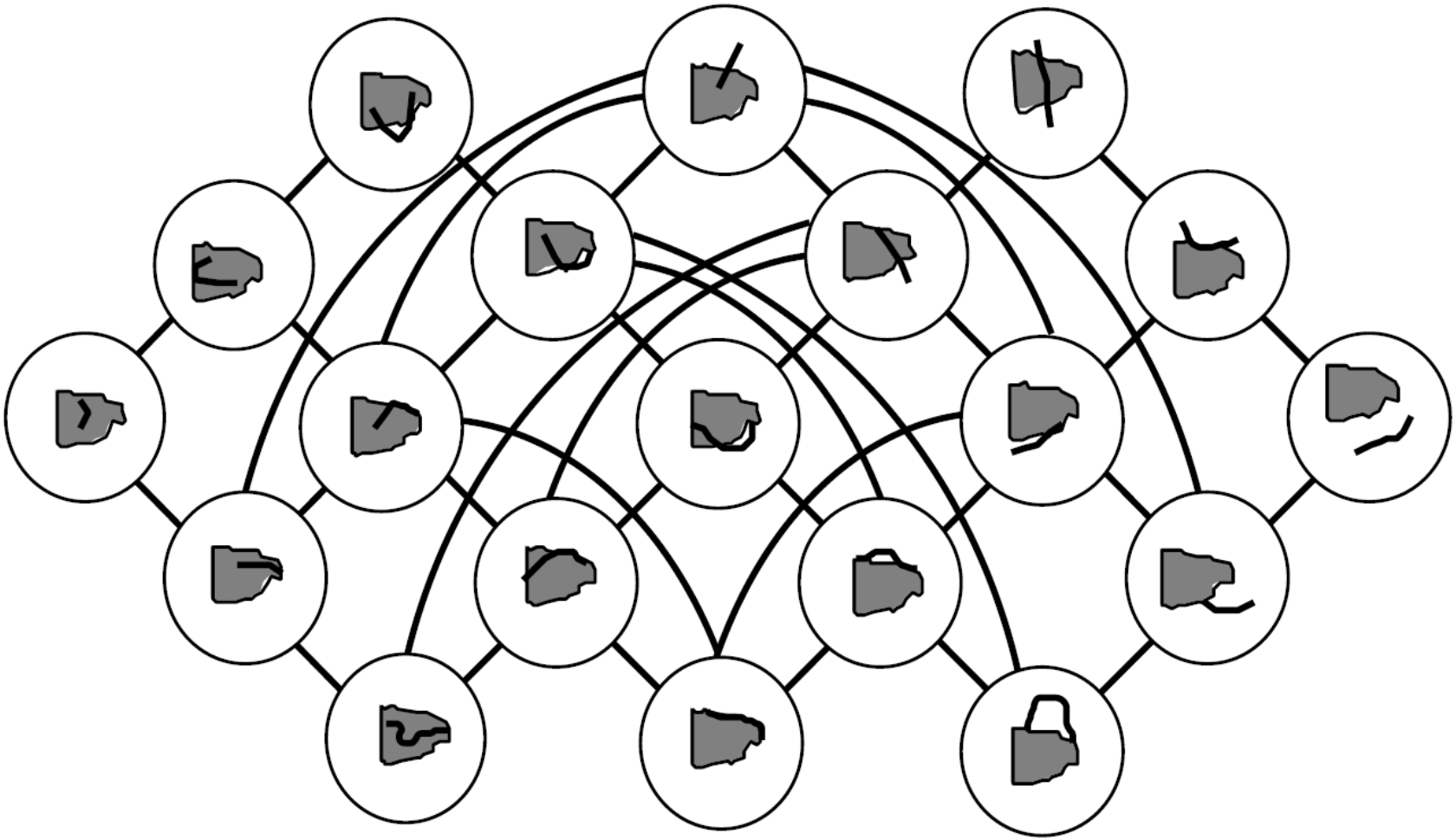
1. If the line's interior intersects with the region's interior *and* exterior, then the line's interior must also intersect with the region's boundary.

$$M[^\circ, ^\circ] = \neg\varnothing \text{and} M[^\circ, ^- ] = \neg\varnothing \Rightarrow M[^\circ, \delta] := \neg\varnothing$$

2. If the line's boundary intersects with the region's interior (exterior) then the line's interior must intersect with the region's interior (exterior) as well.

$$M[\delta, ^\circ] = \neg\varnothing M[^\circ, ^\circ] := \neg\varnothing$$
$$M[\delta, ^- ] = \neg\varnothing M[^\circ, ^- ] := \neg\varnothing$$

# Resulting Neighborhood Graph



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