

Abstracting and Formalizing Model Generalization

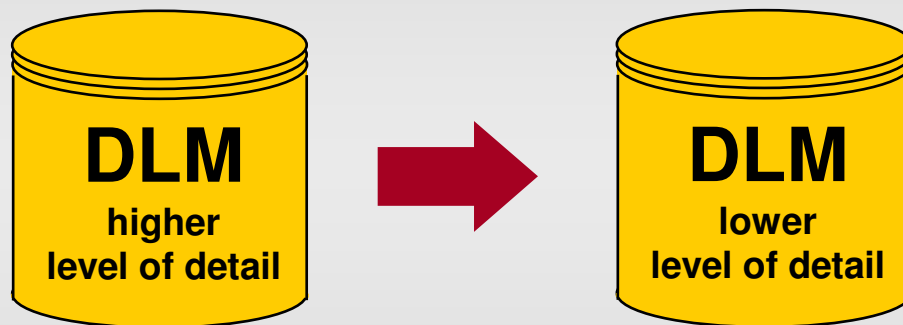
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Model Generalization

DLM: Digital Landscape Model



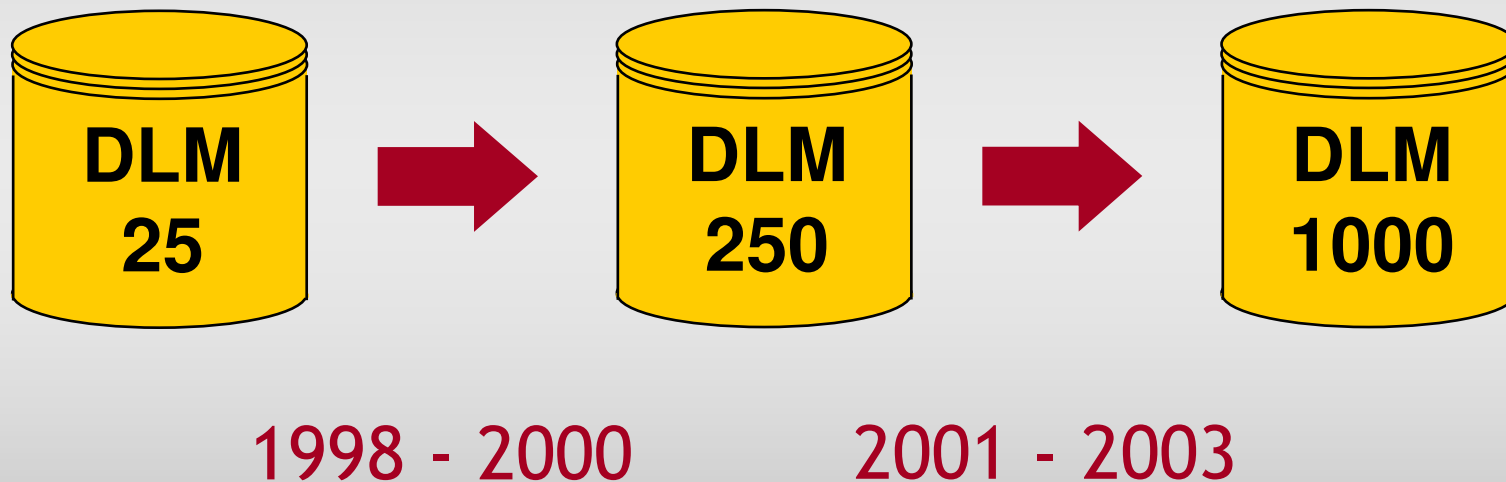
Model Generalization

Model Generalization:

- database level
- not aiming at graphical presentation
- e.g. no displacements
- important issue: **data integrity**

Model Generalization

DLM: Digital Landscape Model

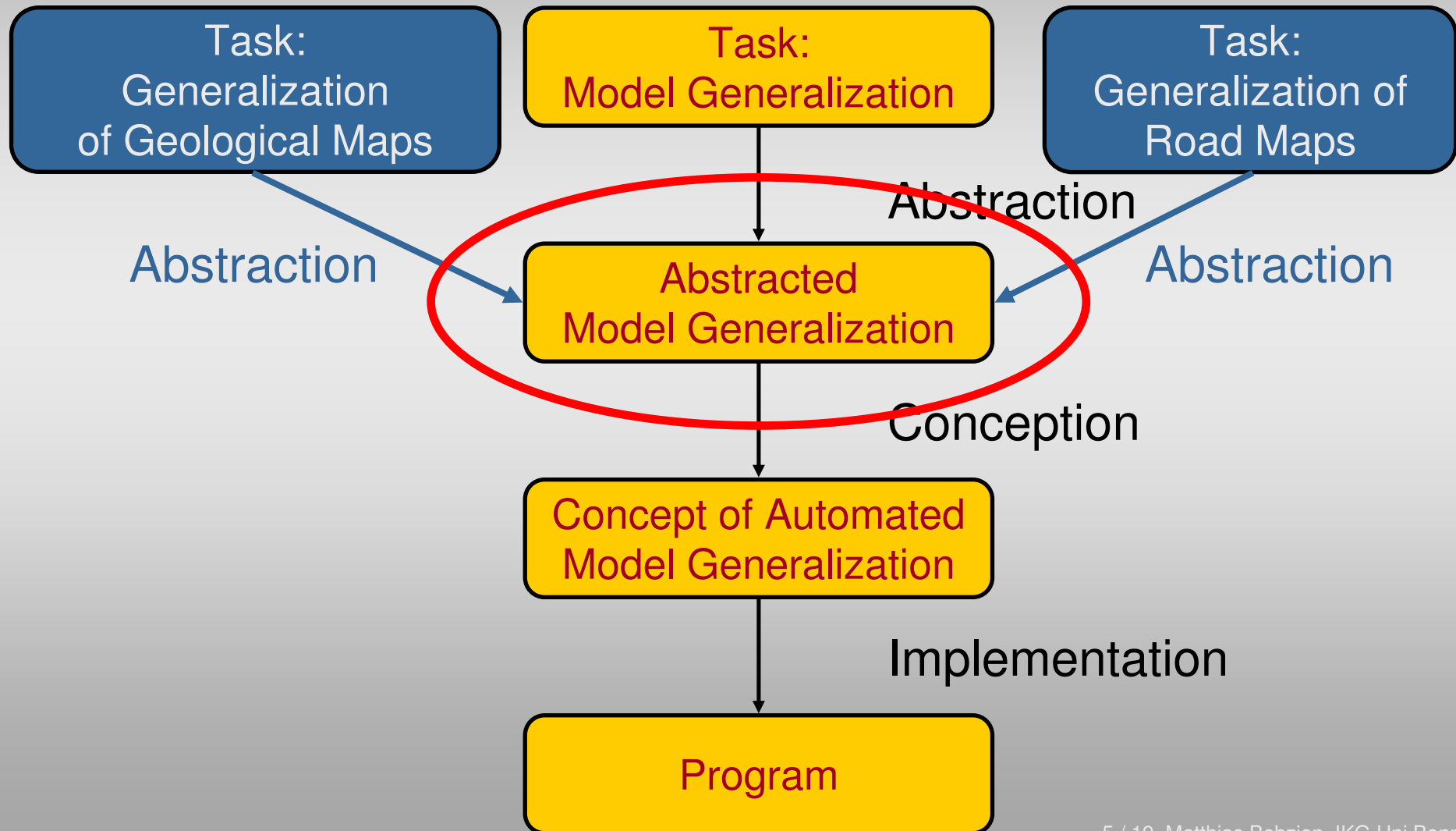


Goal: Identification of resolution-independent elements

Motivation

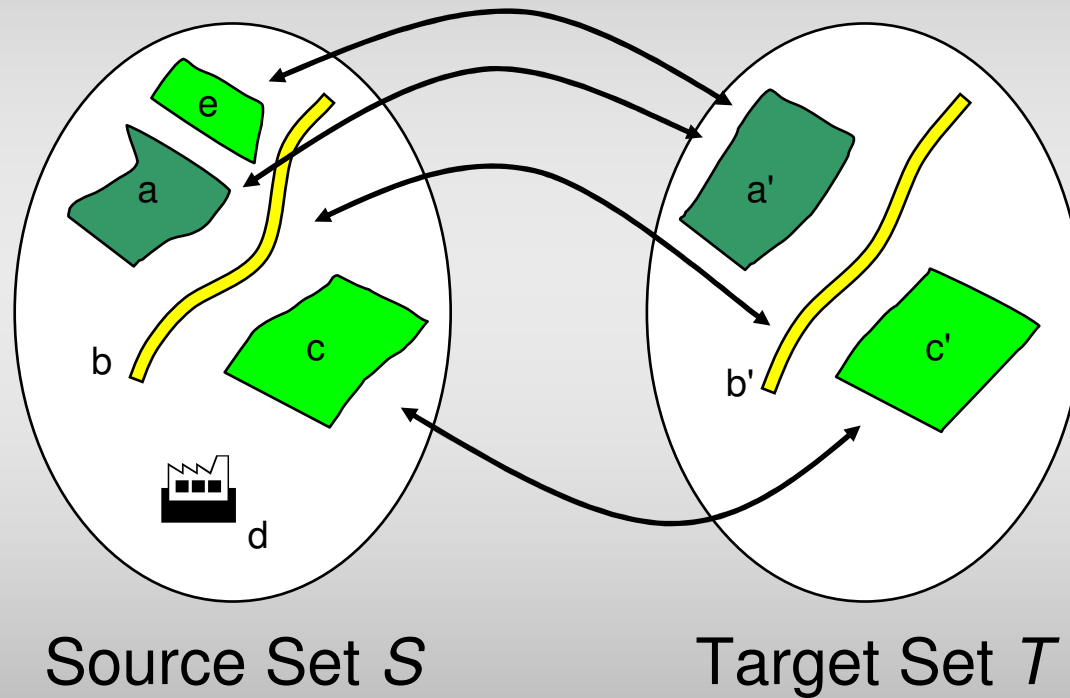
- Goal: Identification of resolution-independent elements
 - ⇐ by abstraction of the generalization process
 - ⇐ by formalization of the generalization process
 - ⇒ Identification of invariant properties
 - ⇒ Integrity constraints
- use these results for other generalization applications?

Abstraction



Formalization

Generalization as a **Relation**:



Relation $R \subseteq S \times T$

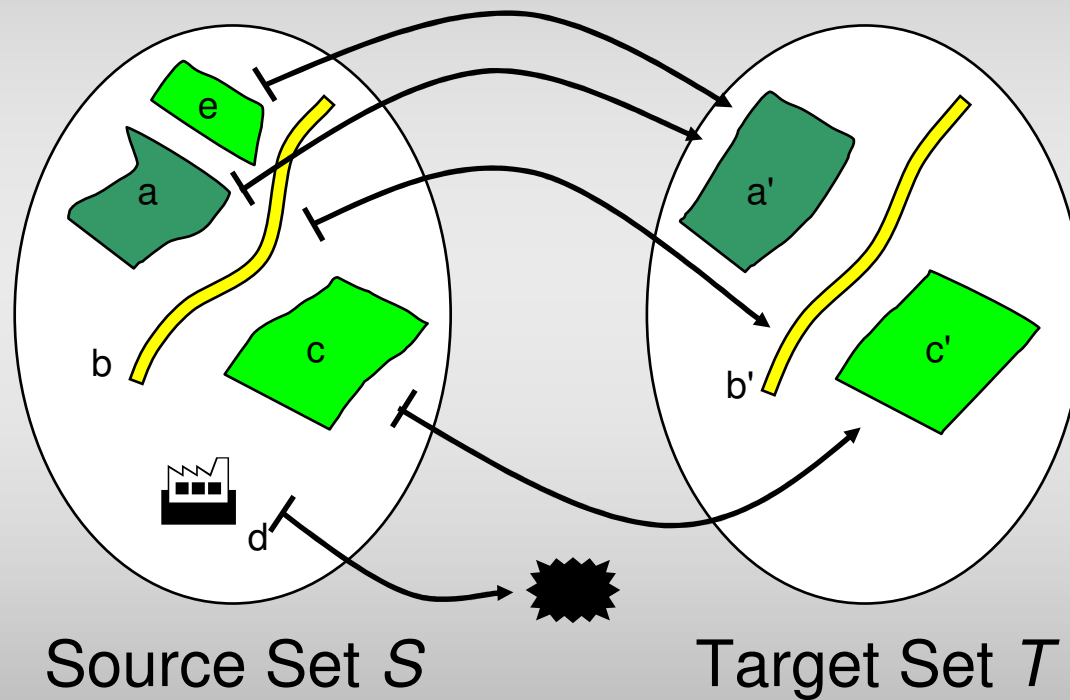
Pairs of Features:
 (a, a') , (b, b') , (c, c') ,
 $(e, a') \in R$

R is not one-to-many

R fulfills the definition
of a function

Formalization

Generalization as a **Function**:



Function $f: S \rightarrow T$

Target Features are
Function Values:

$$f(a) = a'$$

$$f(b) = b'$$

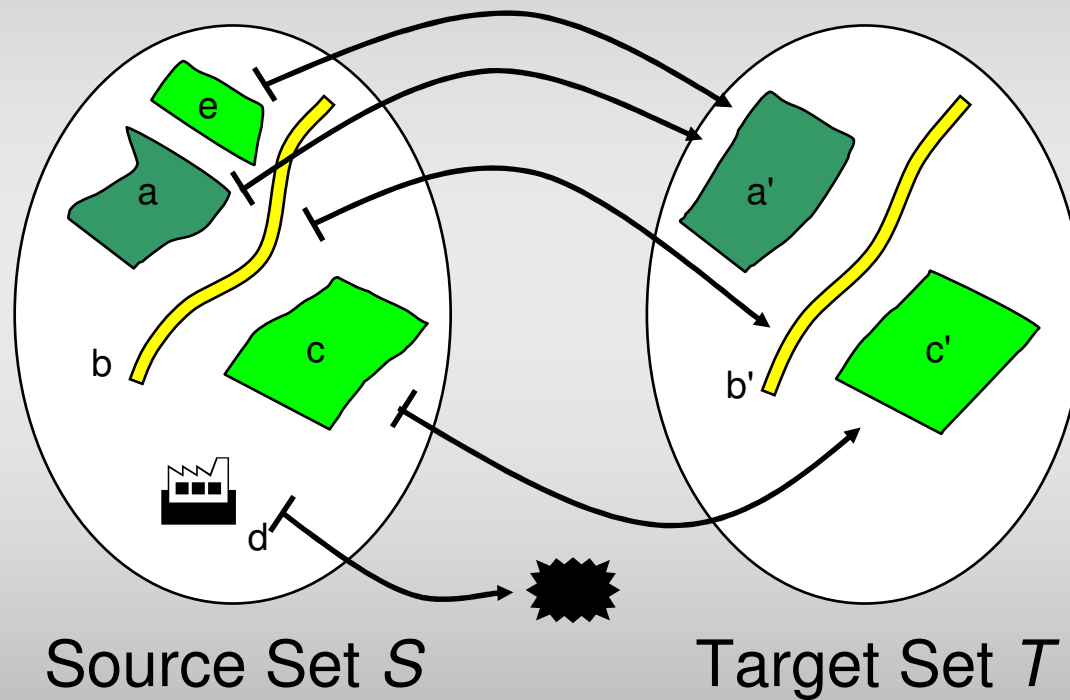
$$f(c) = c'$$

$f(d)$ is not defined

$$f(e) = a'$$

Formalization

Generalization as a **Function**:



Function $f: S \rightarrow T$

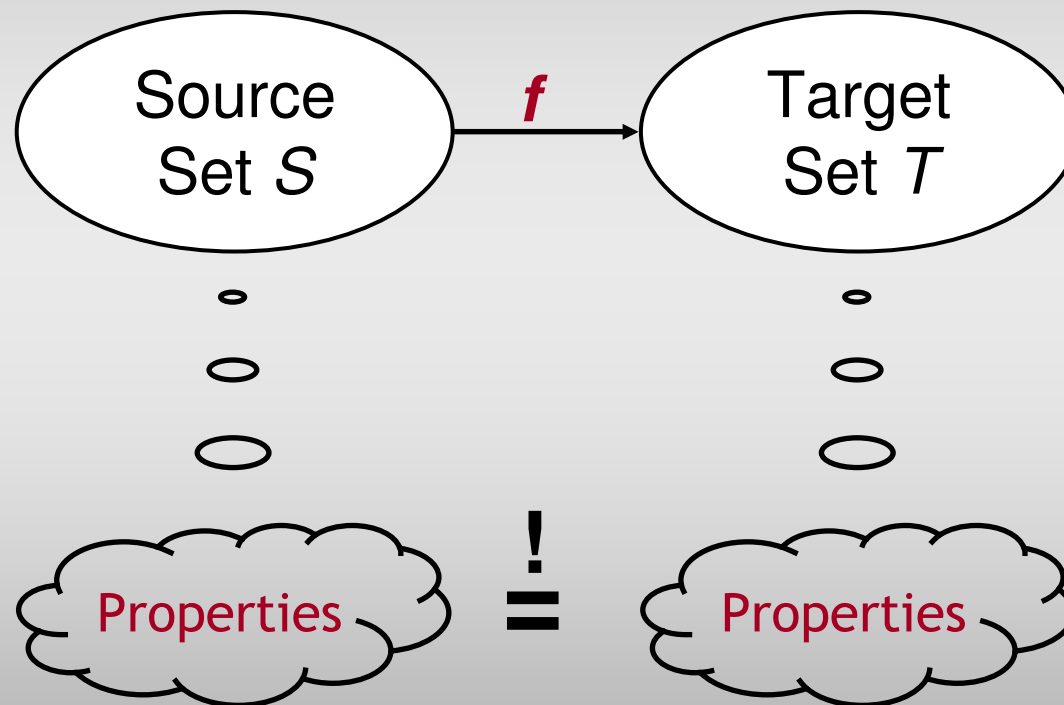
f is *not injective*

f is *surjective*

f is *partial (not total)*

Formalization

Characterization of **Function f** :



- Function f is invariant with respect to these properties.
- f forms a morphism
- goal: identify **invariant properties**

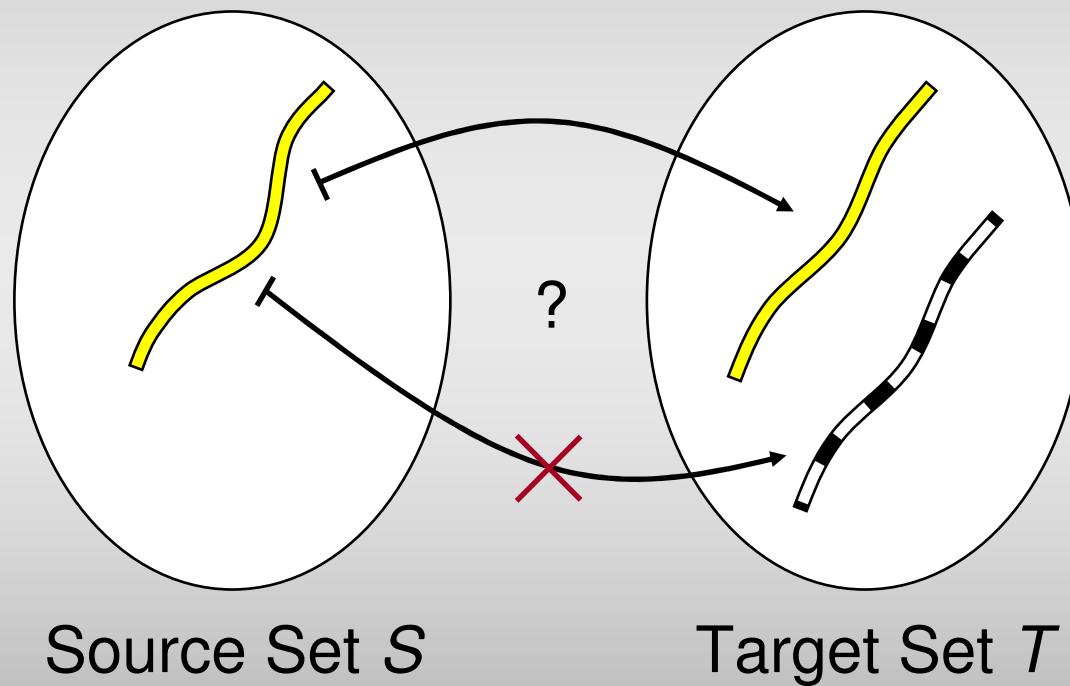
Formalization

Categories of Properties:

- non-spatial properties
 - topological properties
 - geometrical properties
-
- combined properties
- } spatial properties

Constraints

Non-spatial Properties:



- Sets are unions of disjoint classes (e.g. road, railway)
- Classes are related:
state road \leftrightarrow road
county road \leftrightarrow road
bridge \leftrightarrow bridge

Constraints

Non-spatial Properties:

$$S = C_1 \cup C_2 \cup \dots \cup C_n \quad (\text{disjoint})$$

$$T = C'_1 \cup C'_2 \cup \dots \cup C'_m \quad (\text{disjoint})$$

$$CR = \{ (C_i, C'_k) \mid \text{elements of } C_i \subset S \text{ might} \\ \text{be generalized into elements of } C'_k \subset T \}$$

- Sets are unions of disjoint classes (e.g. road, railway)
- Classes are related: state road \leftrightarrow road
county road \leftrightarrow road
bridge \leftrightarrow bridge

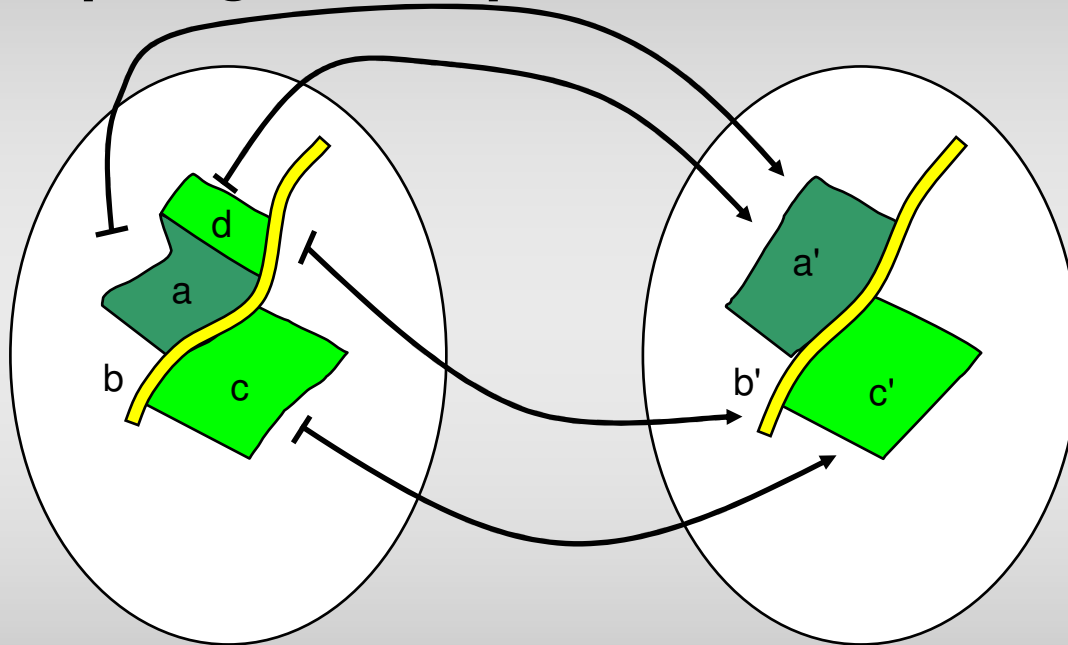
Constraint:

For each $x \in C_i$, $x' \in C'_k$ must hold:

$$f(x) = x' \Rightarrow (C_i, C'_k) \in CR$$

Constraints

Topological Properties:



Relations:

- Adjacency + Incidence

$$N(a, b) \Rightarrow N(f(a), f(b)) \\ = N(a', b')$$

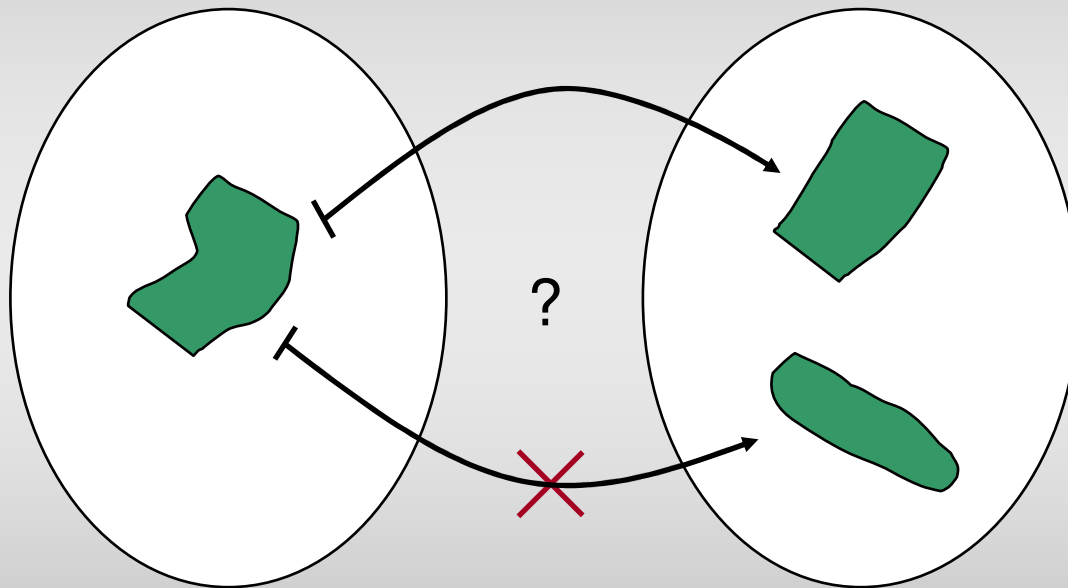
Constraint:

For each pair $x, y \in S$ must hold:

$$N(x, y) \Rightarrow N(f(x), f(y))$$

Constraints

Geometrical Properties:

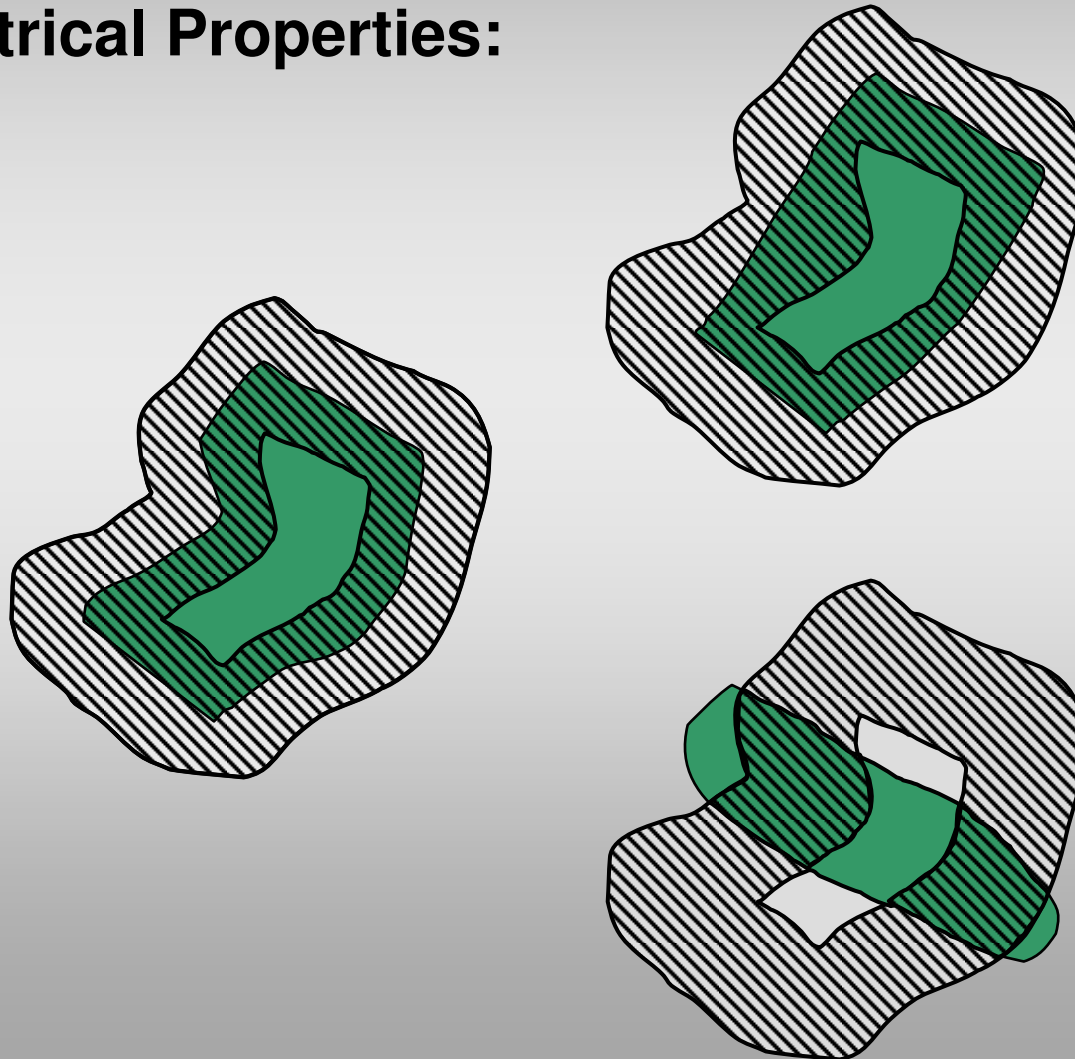


Example:

- Tolerance Corridor (Douglas-Peucker)

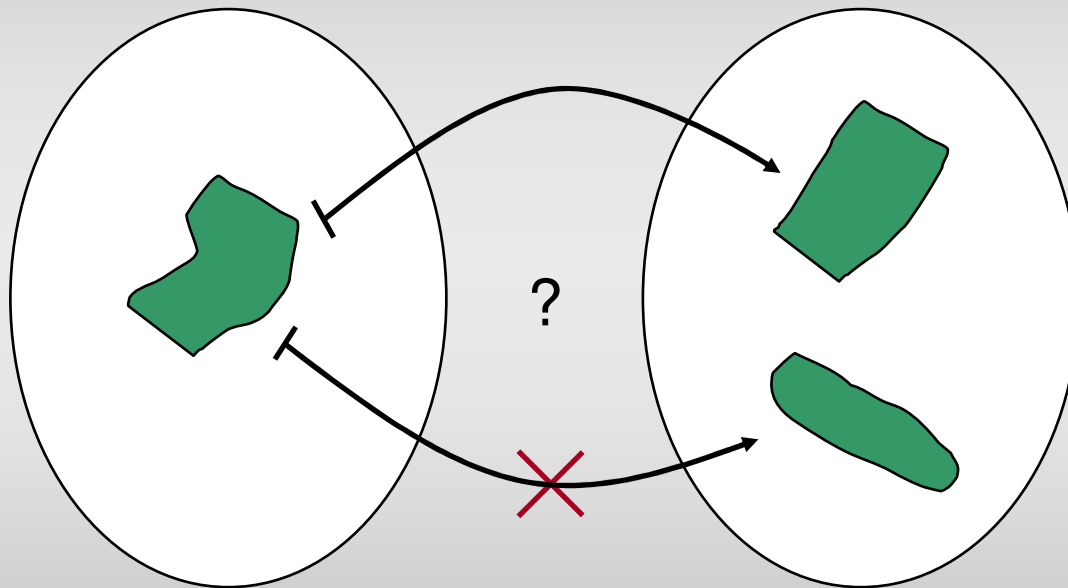
Constraints

Geometrical Properties:



Constraints

Geometrical Properties:



Example:

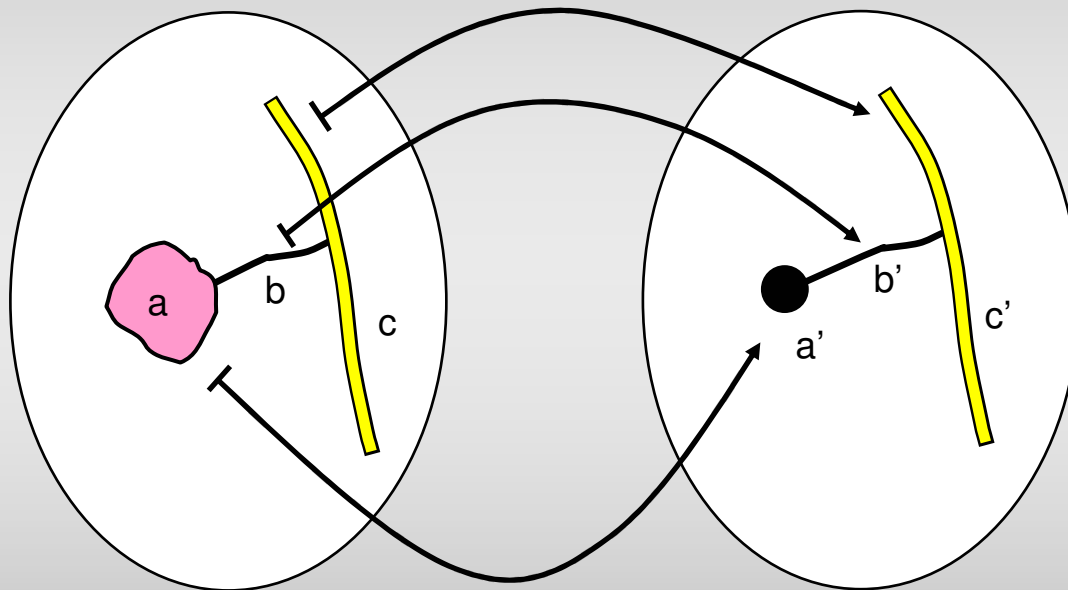
- Tolerance Corridor (Douglas-Peucker)

Other Constraints:

- Number of Control Points
- Distortion Polygon
- Displacement Vectors

Constraints

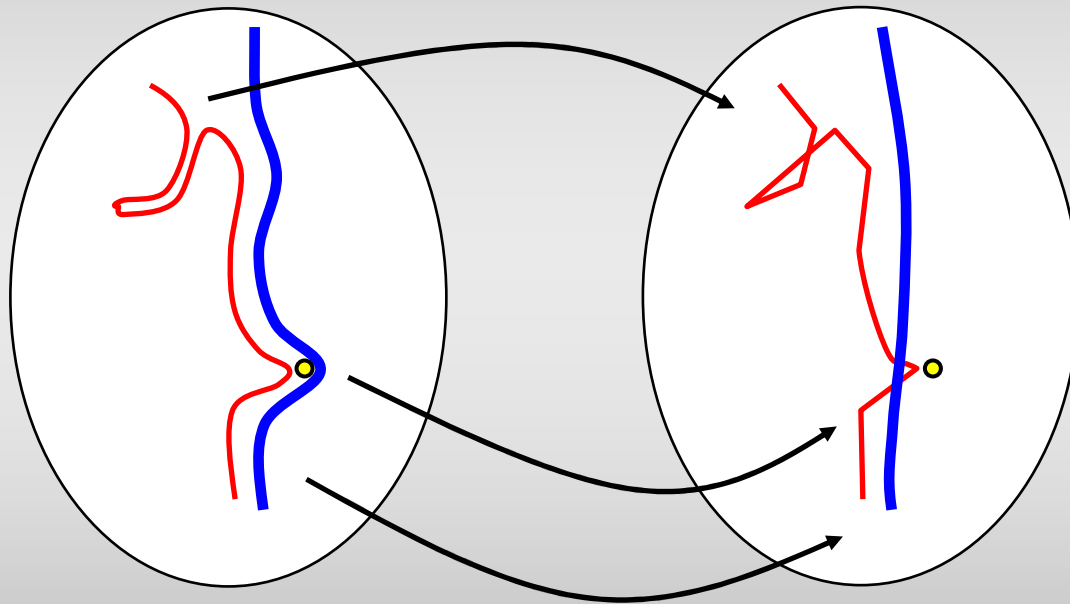
Combined Properties:



- Reachability / Net Connectivity

Constraints

Combined Properties:



- Reachability / Net Connectivity
- Topological Consistency during Line Simplification

Conclusion

- Formalization of the generalization process
- Abstraction of model generalization
- Constraints were found
- Some Constraints are transferable
- e.g. reachability → road-map generalization
- e.g. non-spatial properties → gen. of geological maps