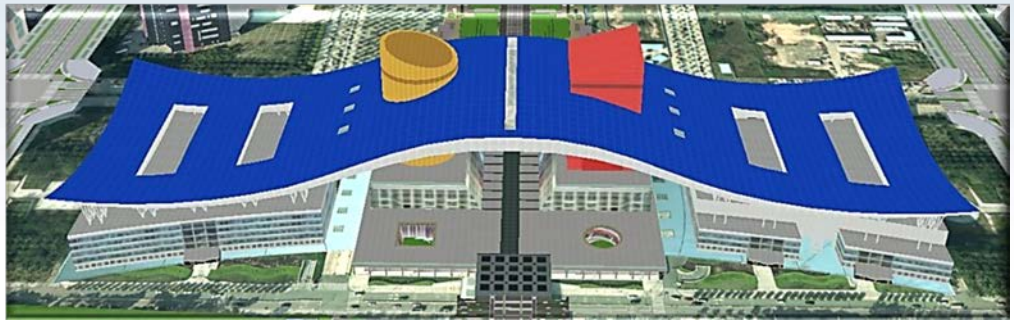


Topological Relationship Identification in 3D Cadastre

Zhigang Zhao

Renzhong Guo, Lin Li, Shen Ying

2012/10/26

1 INTRODUCTION

CADASTRE SPACE (the space of a parcel unit)

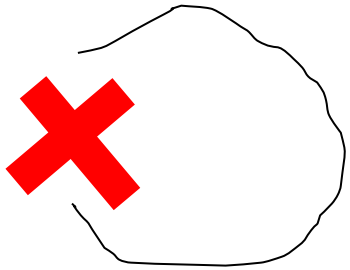
Connected

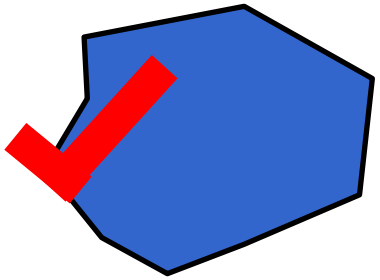
Closed

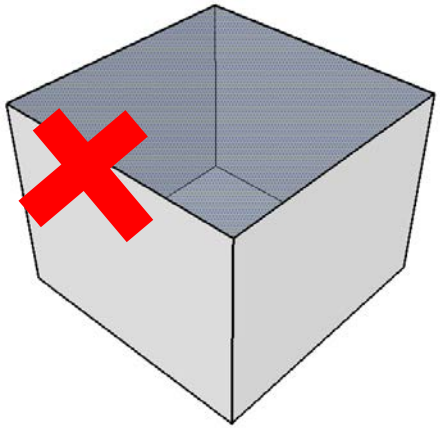
homogenous

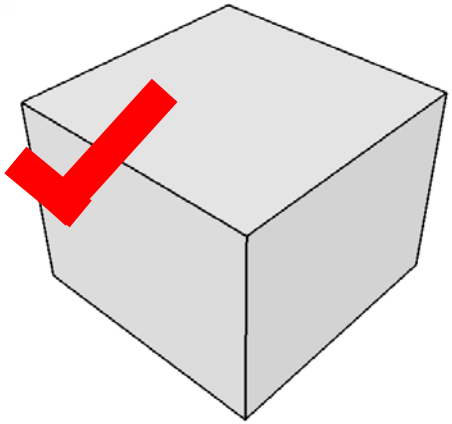
2D

3D









1 INTRODUCTION

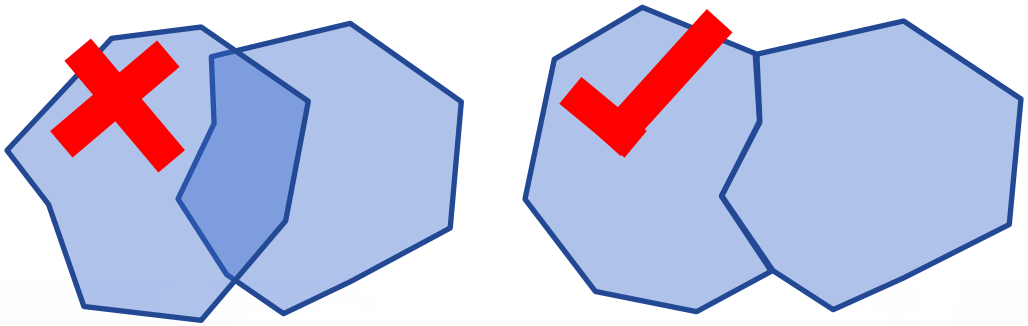
CADASTRE SPACE (the space among parcel units)

Unique

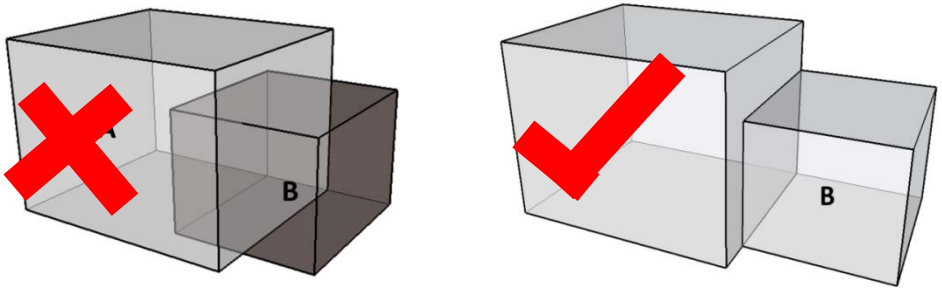
Exclusive

no overlap

2D



3D

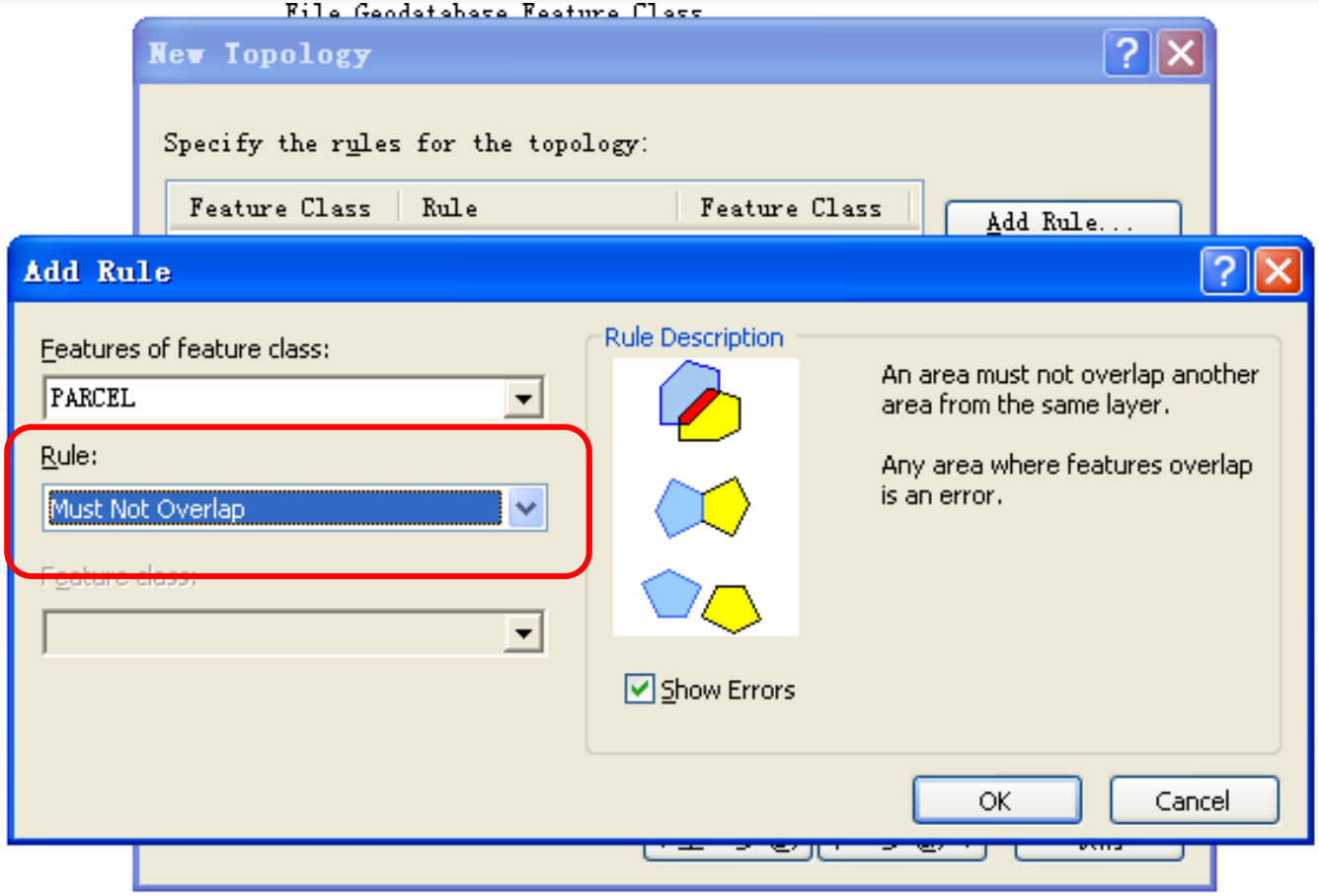


1 INTRODUCTION

2D CADASTRE SPACE VALIDATION

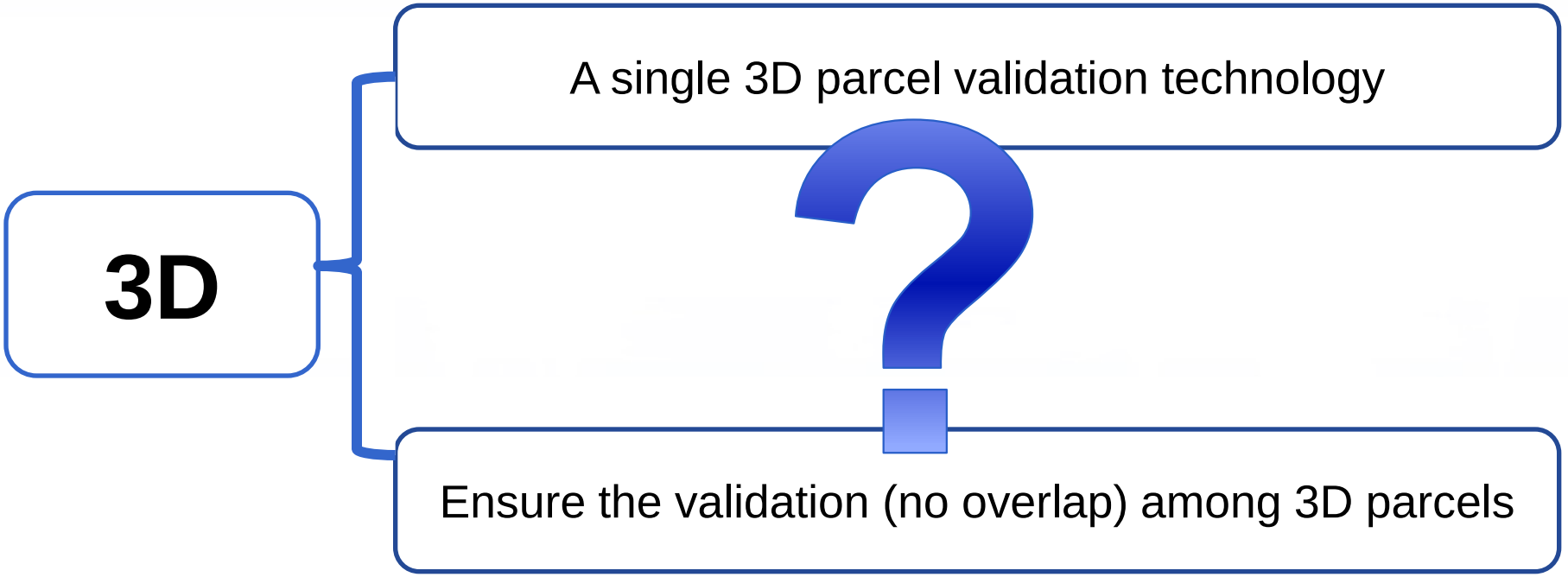
2D

ARCGIS



1 INTRODUCTION

3D CADASTRE SPACE VALIDATION



2 3D VALIDATION

3D CADASTRE SPACE VALIDATION

- Verbree and Hang Si (2008) have employed Constrained Delaunay Tetrahedralization (CDT) to check the validity of a single 3D polyhedron.
- Brugman et al. (2011) developed a series of topological rules to validate a 3D topology structure for a 3D space partition.
- Thompson and Peter Van Oosterom (2011) extended these rules to axiomatic definitions to validate a 3D parcel and its relationship with adjoining parcels

2 3D VALIDATION

3D CADASTRE SPACE VALIDATION

- Karki et al. (2011) specifically discussed the data validation in 3D cadastre including a single 3D parcel and its relationships with other parcels.

2 3D VALIDATION

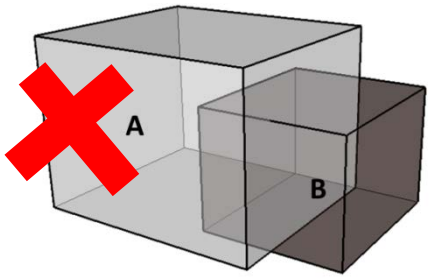
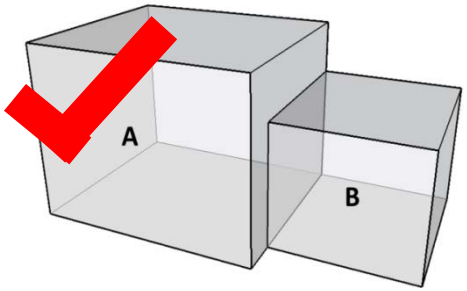
3D CADASTRE SPACE VALIDATION

The four papers introduced or discussed the validation methods or rules mainly for single 3D parcle using computational geometry or topology rules.

But as to 3D topological relations identification, it needs more study to design practical algorithms or methods. And this paper will introduce a case for it.

3 TOPOLOGICAL RELATIONS

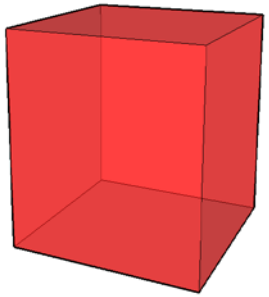
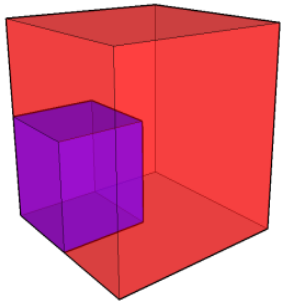
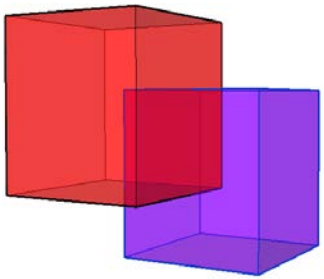
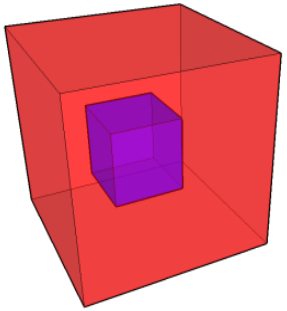
Correct and incorrect topological relations

	incorrect	correct
Topological relations		
Basic Granularity	**There is intersections between A and B** → Equal, Intersect Cover, Contain	**There is no intersections between A and B** → Touch, Disjoint

3 TOPOLOGICAL RELATIONS

incorrect topological relations

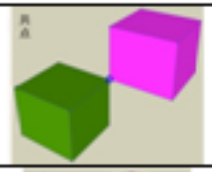
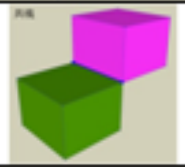
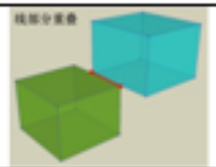
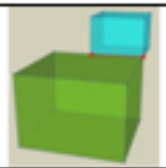
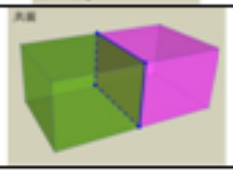
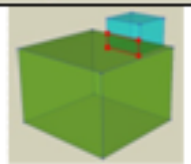
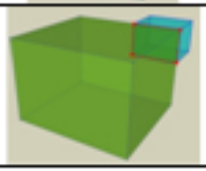
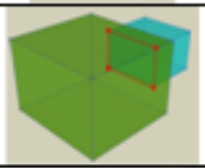
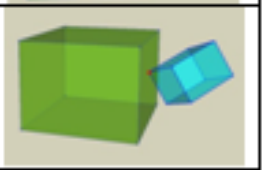
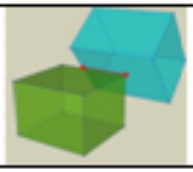
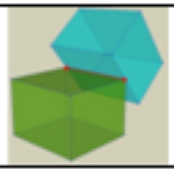
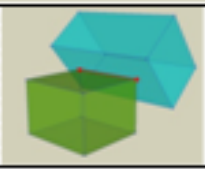
Basic Granularity

equal	cover	intersect	contain
			

3 TOPOLOGICAL RELATIONS

Correct topological relations in basic granularity

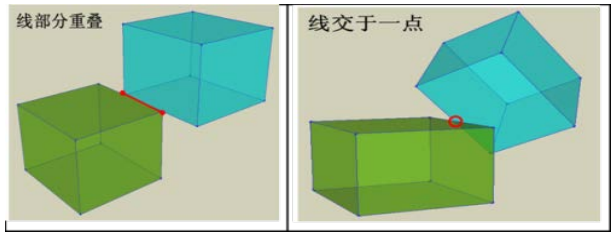
Touch relations in Dimension-Extended Model

rimitiv es	Detailed primitive s	Equal	Intersect	Cover	Contain
Betwee n iD primitiv e and jD primitiv e (i=j)	Point and Point		None	None	None
	Edge and Edge				
	Face and Face				
Betwee n iD primitiv e and jD primitiv e (i!=j)	Point and Edge	None	None	None	
	Point and Face	None	None	None	
	Edge and Face	None			

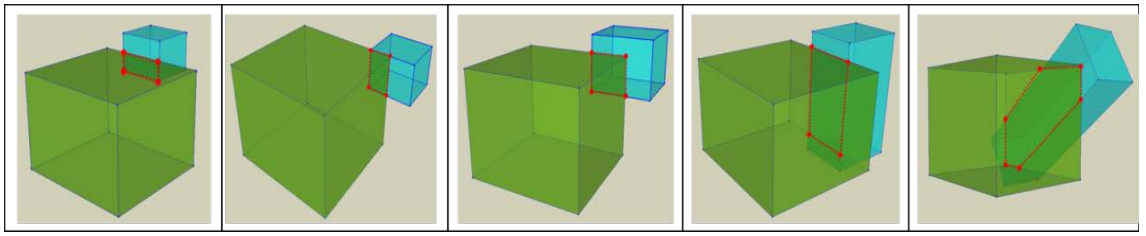
3 TOPOLOGICAL RELATIONS

correct topological relations —— touch extension

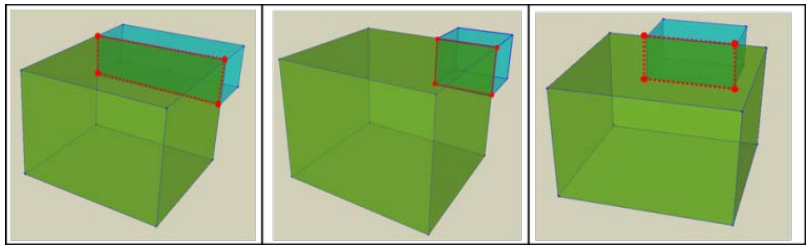
Edges Intersection



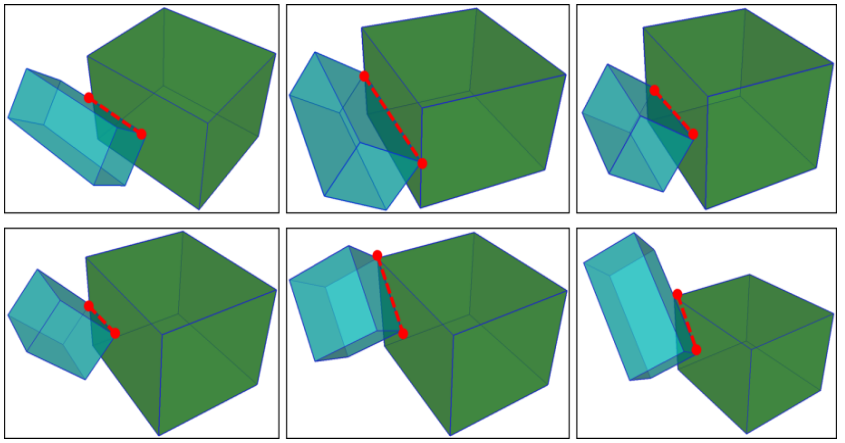
Faces intersection



Face covers face

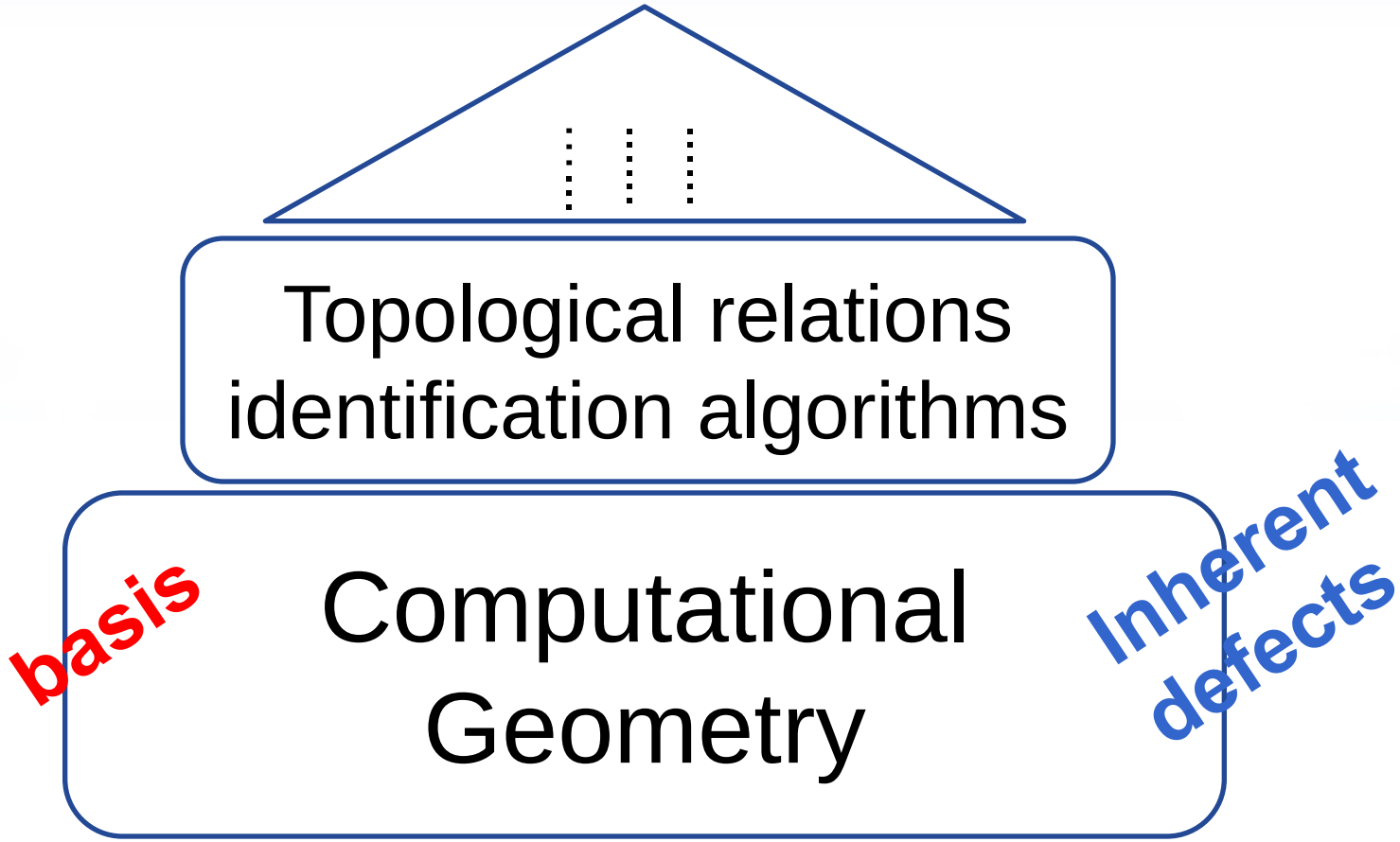


Face covers edge



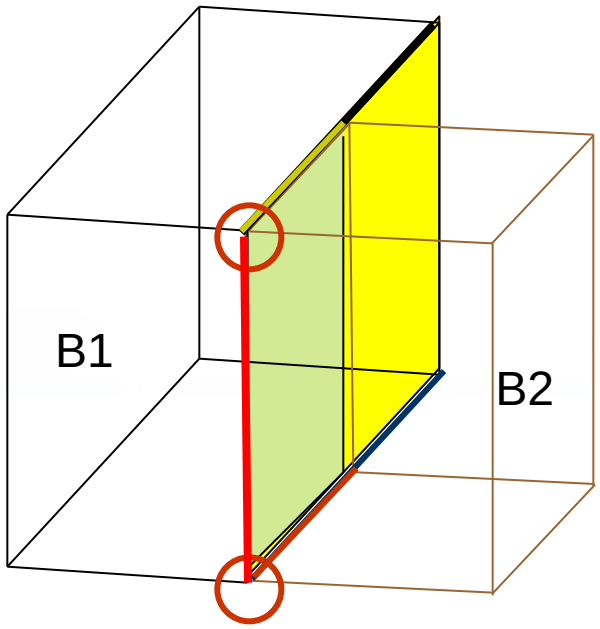
4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

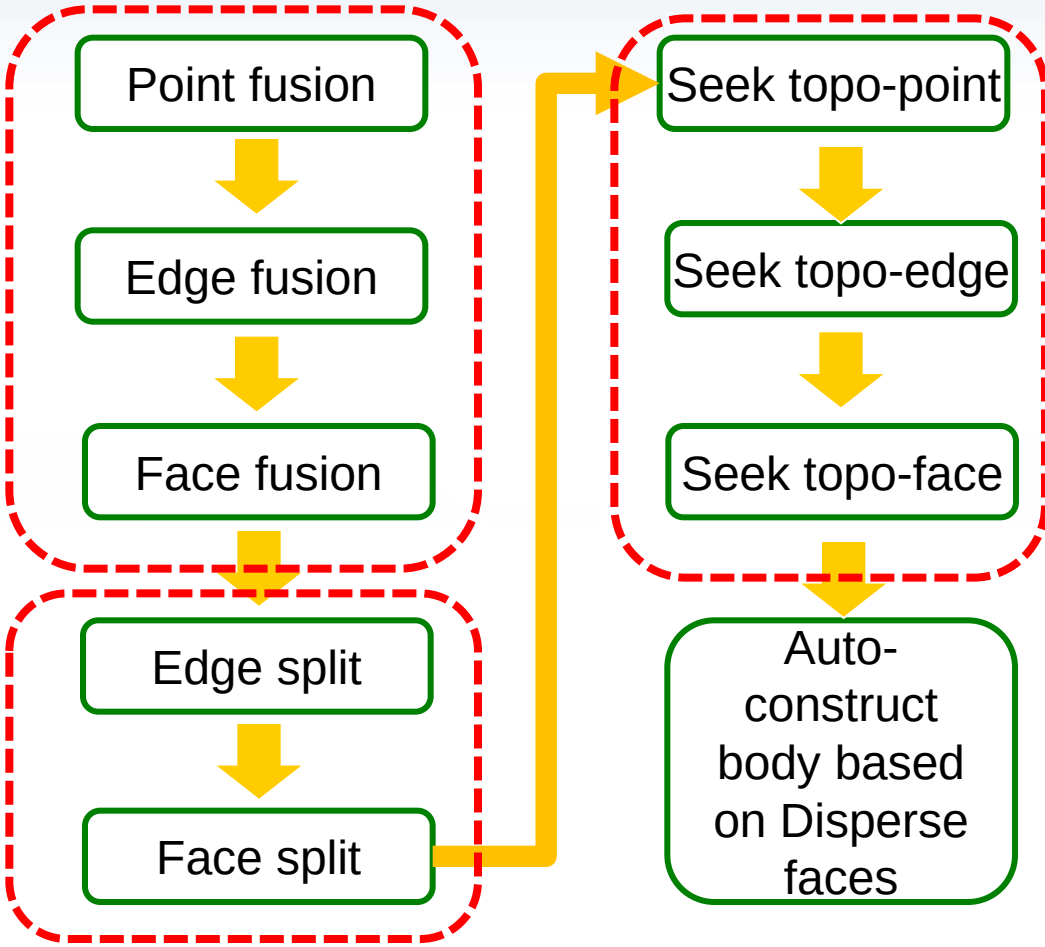
The basis of topological relations identification



4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

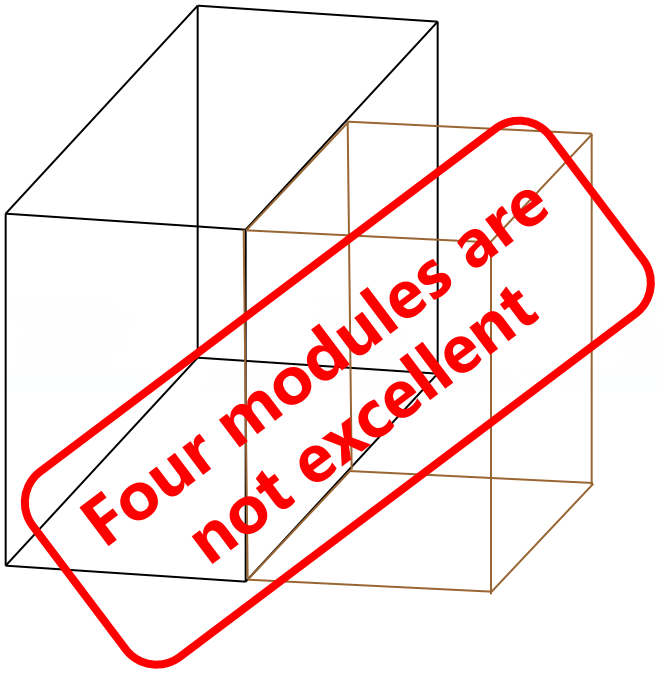
Automatically body-construct algorithm





4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm



Redundant primitives unique

public part split

Seek topo-primitives

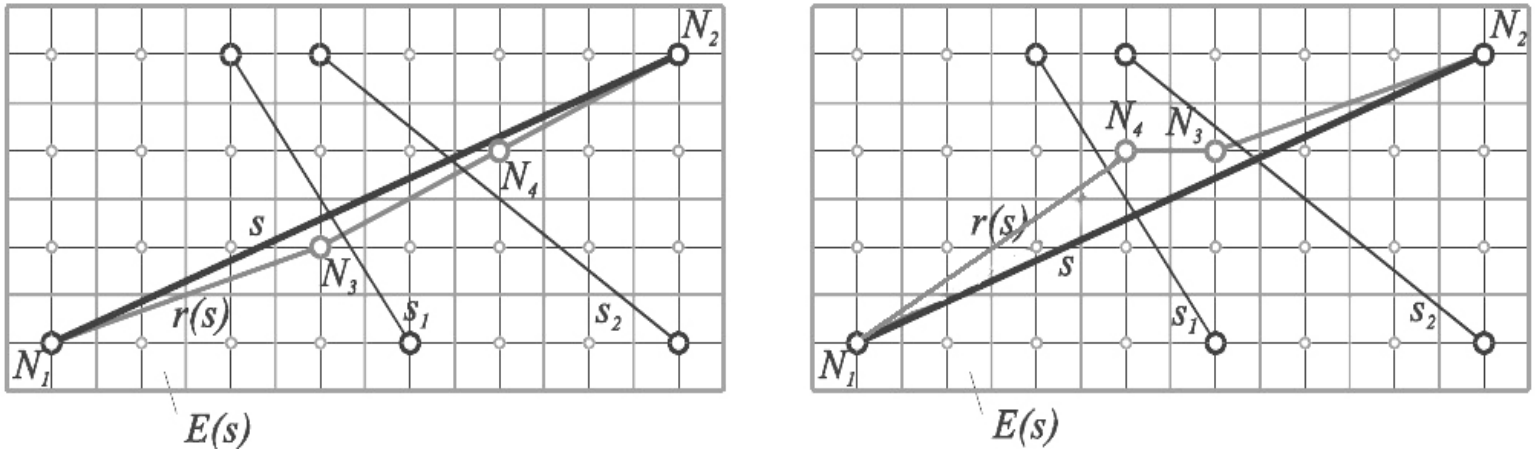
Auto-construct body based on Disperse faces

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm

Split defect

Edge split : The results not unique



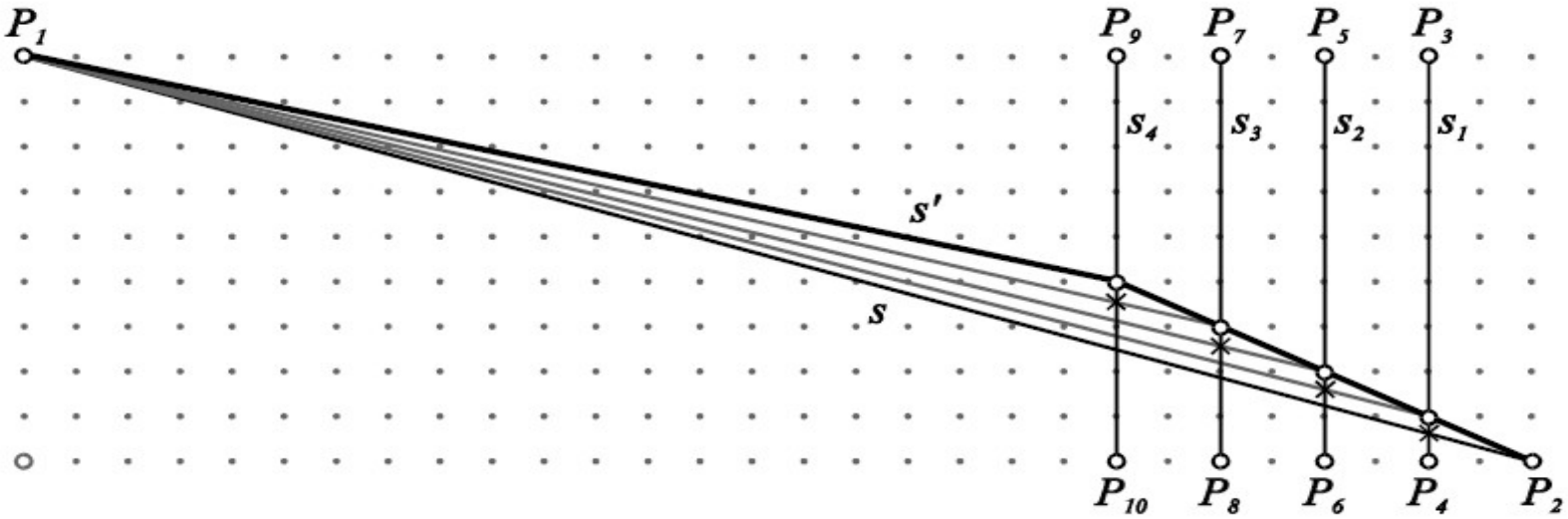
Werner Hölbling, Werner Kuhn, Andrew U. Frank. Finite-Resolution Simplicial Complexes

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm

Split defect

Edge split : Cumulative offset



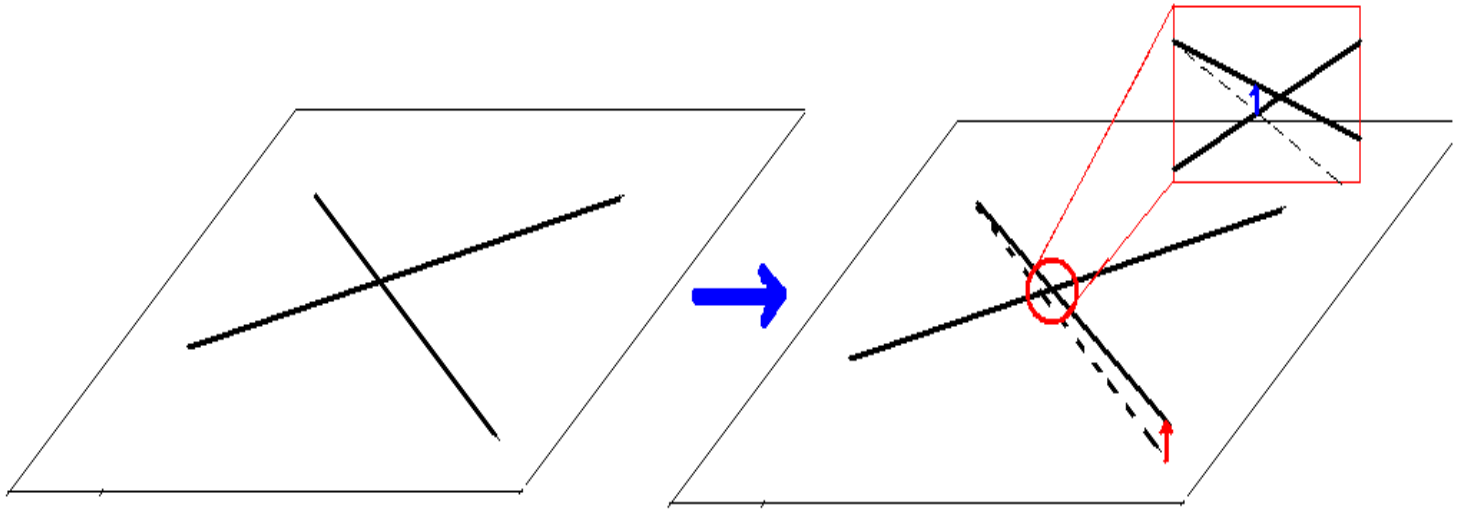
Werner Hölbling, Werner Kuhn, Andrew U. Frank. Finite-Resolution Simplicial Complexes

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm

Split defect

Edge split : Data perturbation

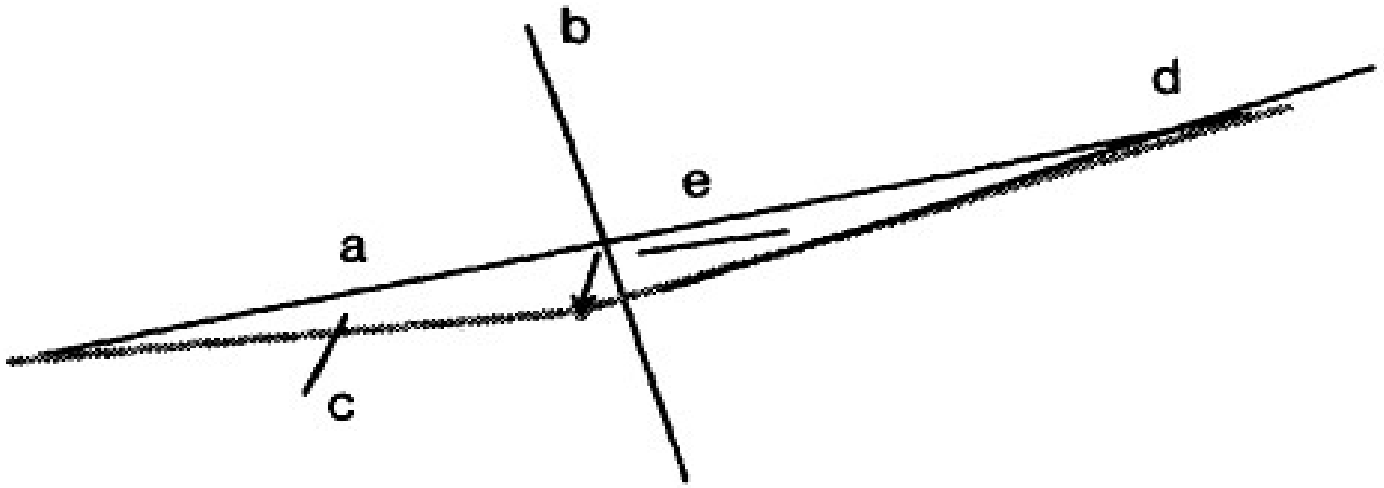


4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm

Split defect

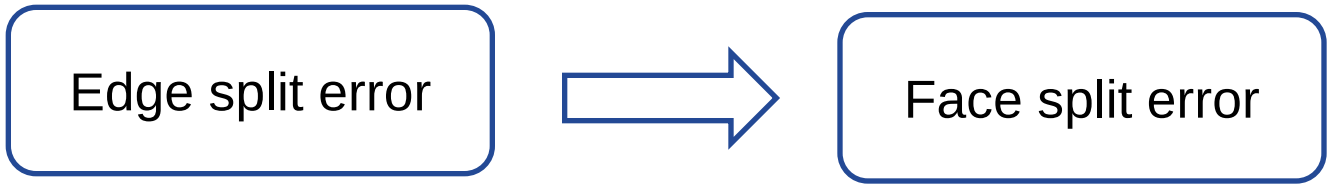
Edge split : Topology inconsistent



Daniel H. Greene, F. Frances Yao. FINITE-RESOLUTION COMPUTATIONAL GEOMETRY

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm



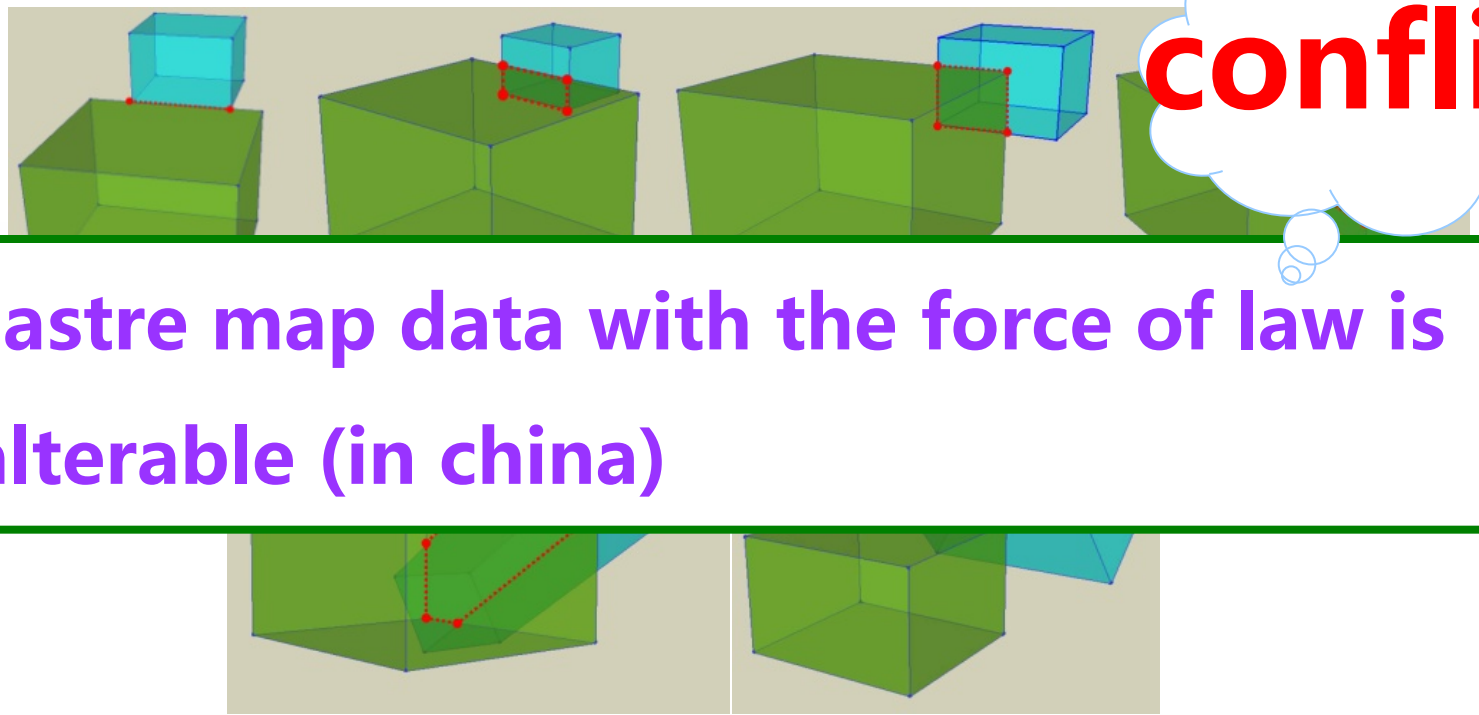
These defects will lead to topology construction failed

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm

Split defect

Edge, face split : add new data



conflict

Cadastre map data with the force of law is Unalterable (in china)

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Automatically body-construct algorithm

These defects are inherent in th… geometry algorithms, and ca… which will bring a series of u… need to seek a new 3D cadastral … topology construction method. This method can cope with the various defects mentioned above, simultaneously ensure the legitimacy of the raw measurement data of a 3D parcel.

Virtual element method

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Virtual element method : Design Purpose

Design purpose

1、Don't break cadastre map data

2、terminate the iterative error by split

3、avoid Geometric element degeneration

4、Different dimensional relations in touch

5、topological check function

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Virtual element method : Core Idea

Virtual element method

core idea

1、roles that represent relations among elements

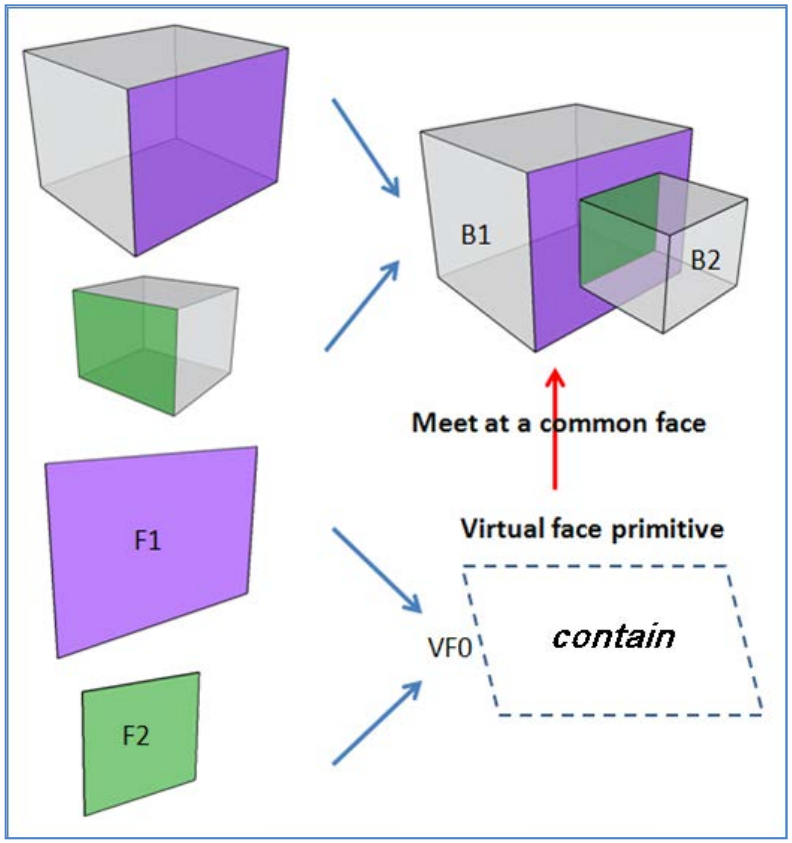
2、boundary combination reasoning method

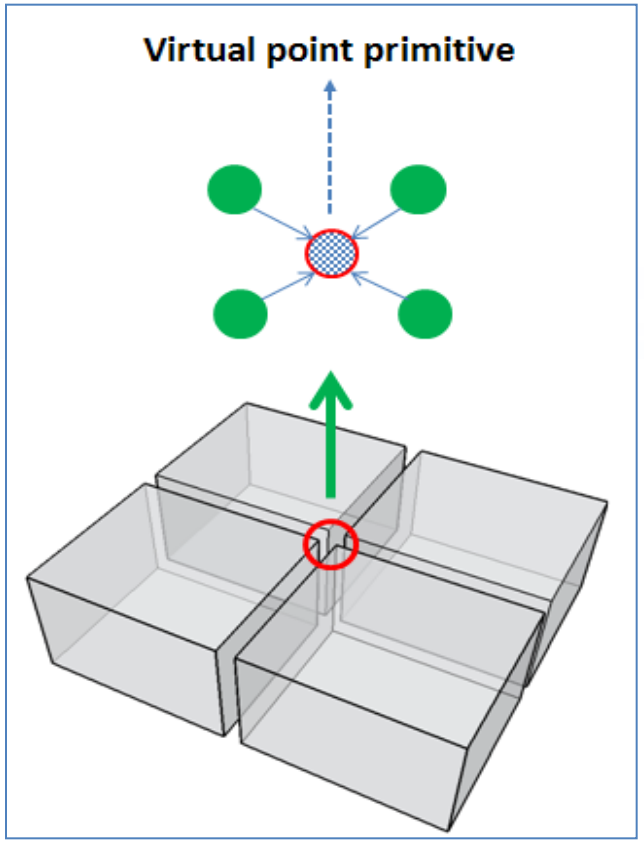
3、 “compact / coupled” topological structure

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

Virtual element method : Core Idea

1、role as virtual element

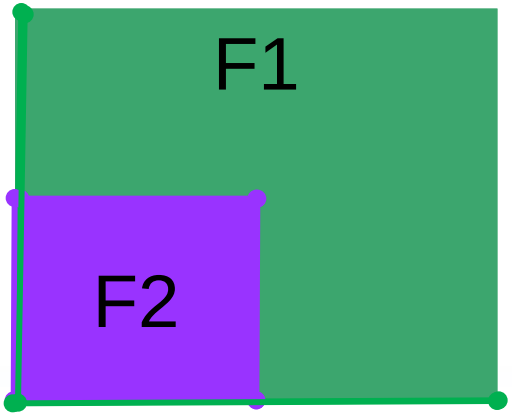




4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

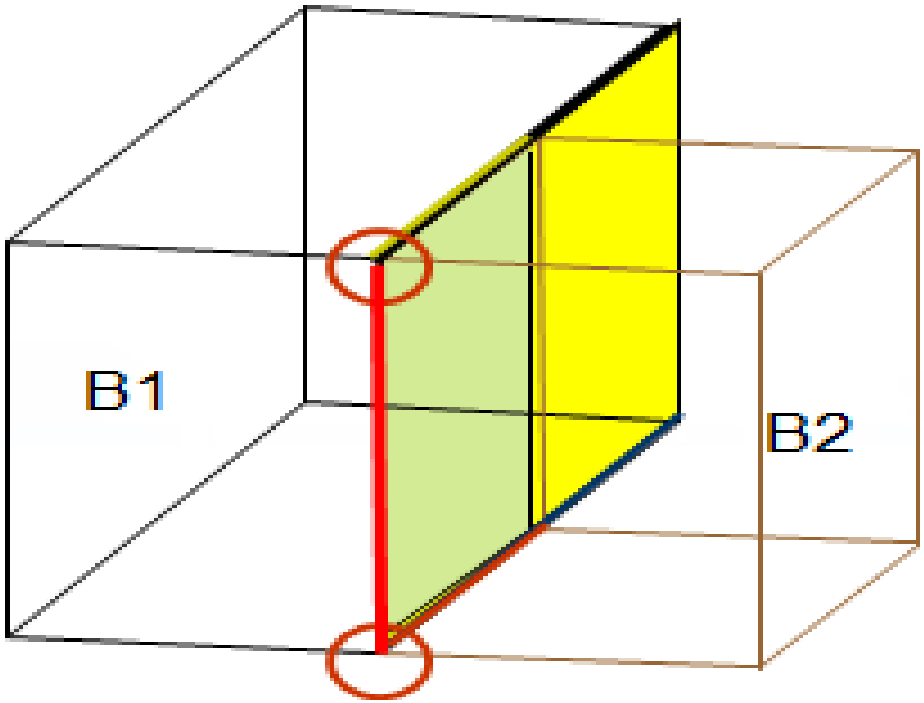
Virtual element method : Core Idea

2、boundary combination reasoning



cover

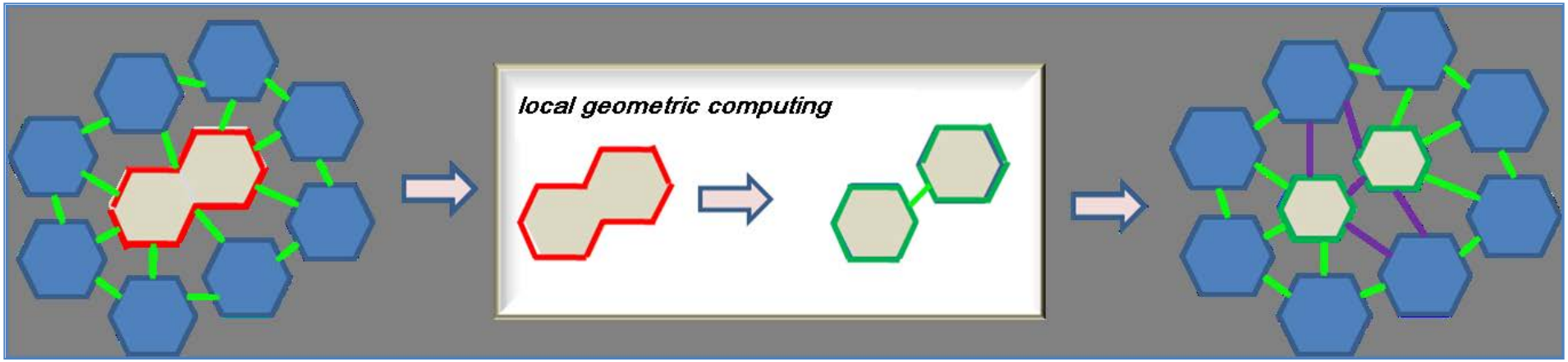
inters
inside



4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

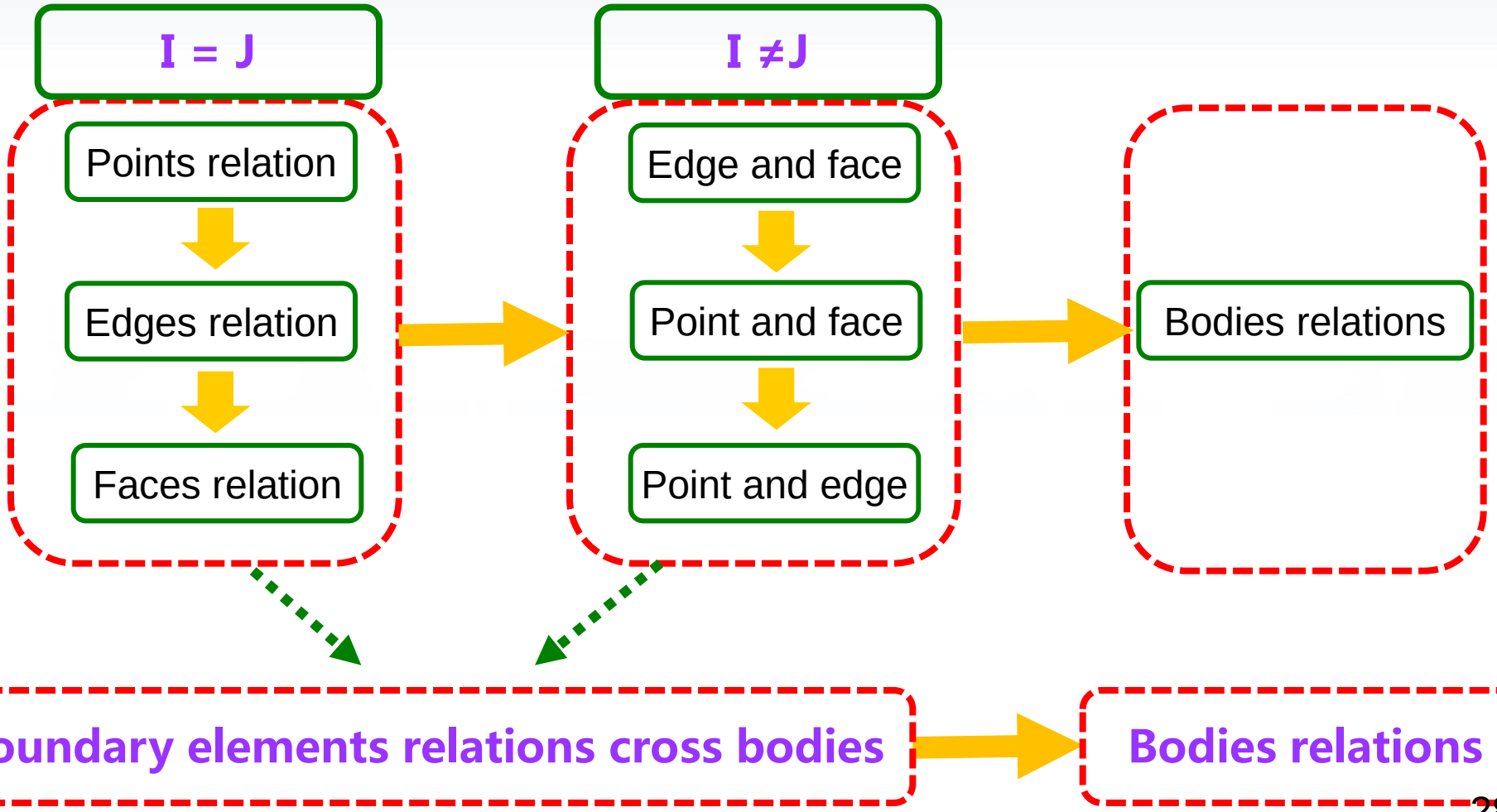
Virtual element method : Core Idea

3、 “compact / coupled” topological structure



4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

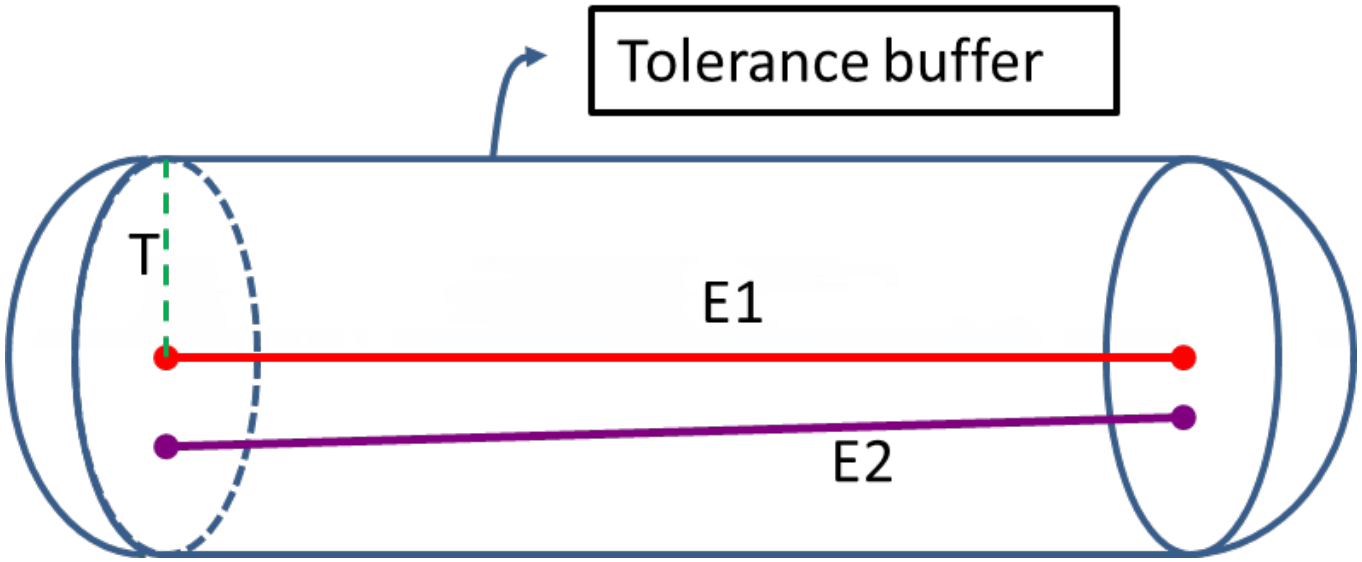
The algorithm design : general process



4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

1 edges relations reasoning in tolerance buffer

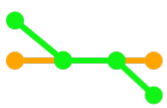
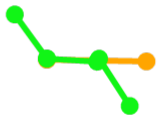
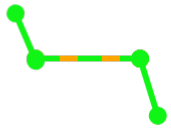
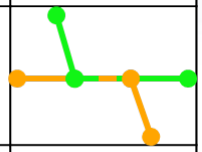
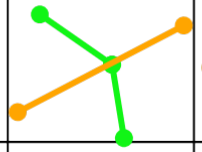
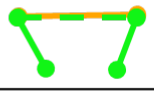
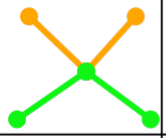
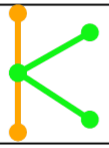


4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

2 faces relations

Boundary combinational reasoning method

两个环交叠于一维 交叠	交叠1	交叠2	交叠3	交叠4
				
	EE3 EE7	EE2 EE4 EE7	EE1 EE4	EE5 EE7
两个环交错于零维 交错	交错1	交错2	交错3	
				
	EE4	EE7	EE6	
两个环重叠于一维 重叠	重叠1	重叠2	重叠3	重叠4
				
	EE3 EE7	EE2 EE4 EE7	EE1 EE4	EE5 EE7
两个环相切于零维 相切	相切1	相切2		
				
	EE4	EE7		

Local relations among arcs

Local relations combination

Faces relations By reasoning

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

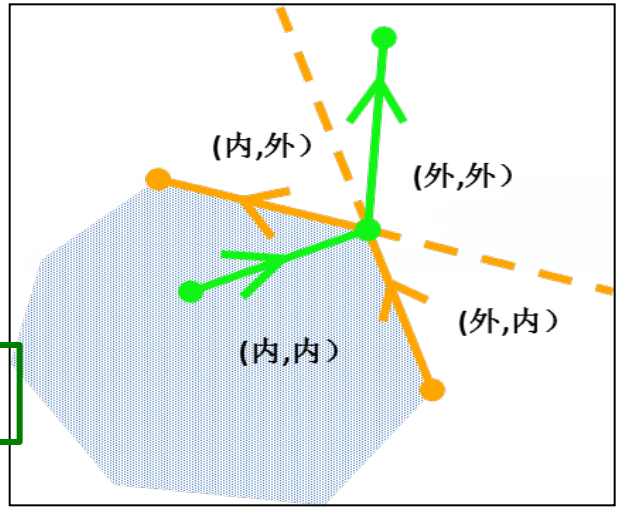
The algorithm design : several core Difficulties

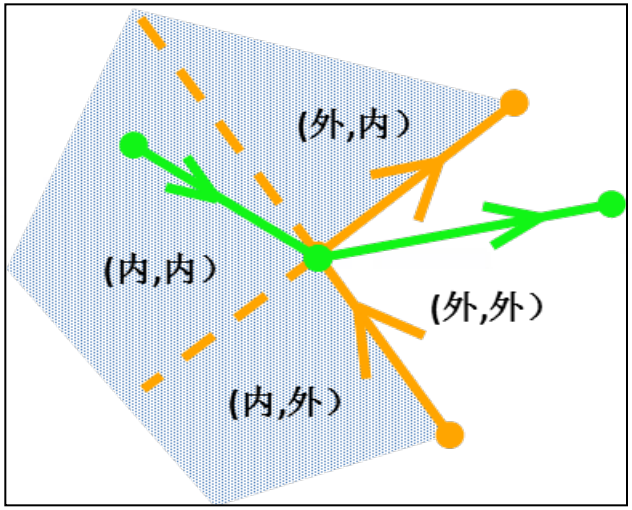
2 faces relations reasoning operator

Local relations Identification

Vector distinguish method

Operator 1





2D space

A collection of four-tuple : S= { (Protruding / Concave),(start/end),(1/2),(1/2)} . The elements is unique and mutually exclusive

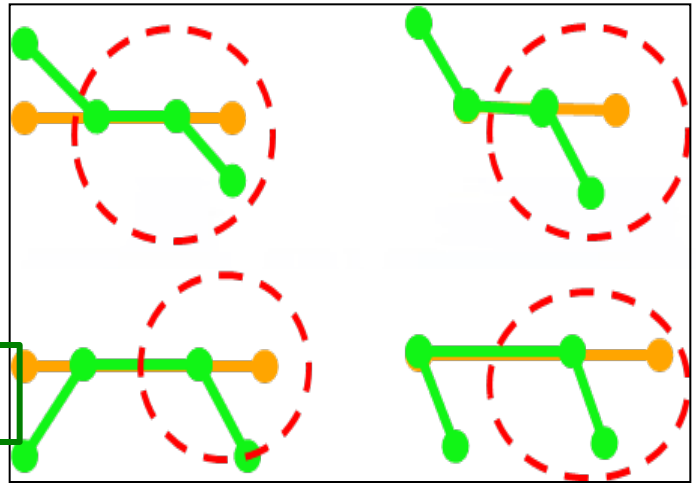
4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

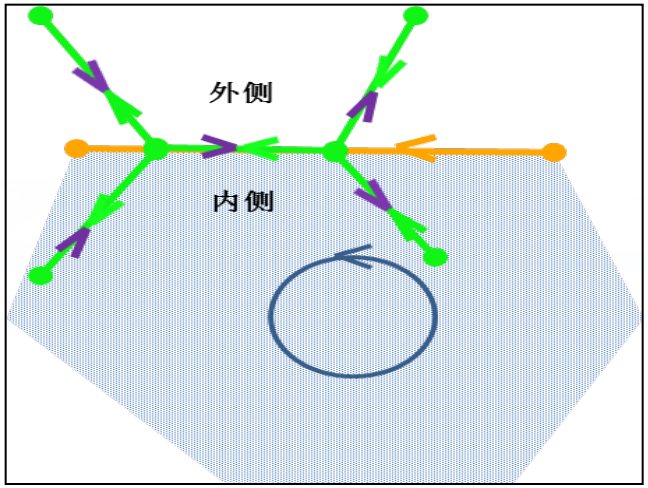
The algorithm design : several core Difficulties

2 faces relations reasoning operator

operator2

2D space





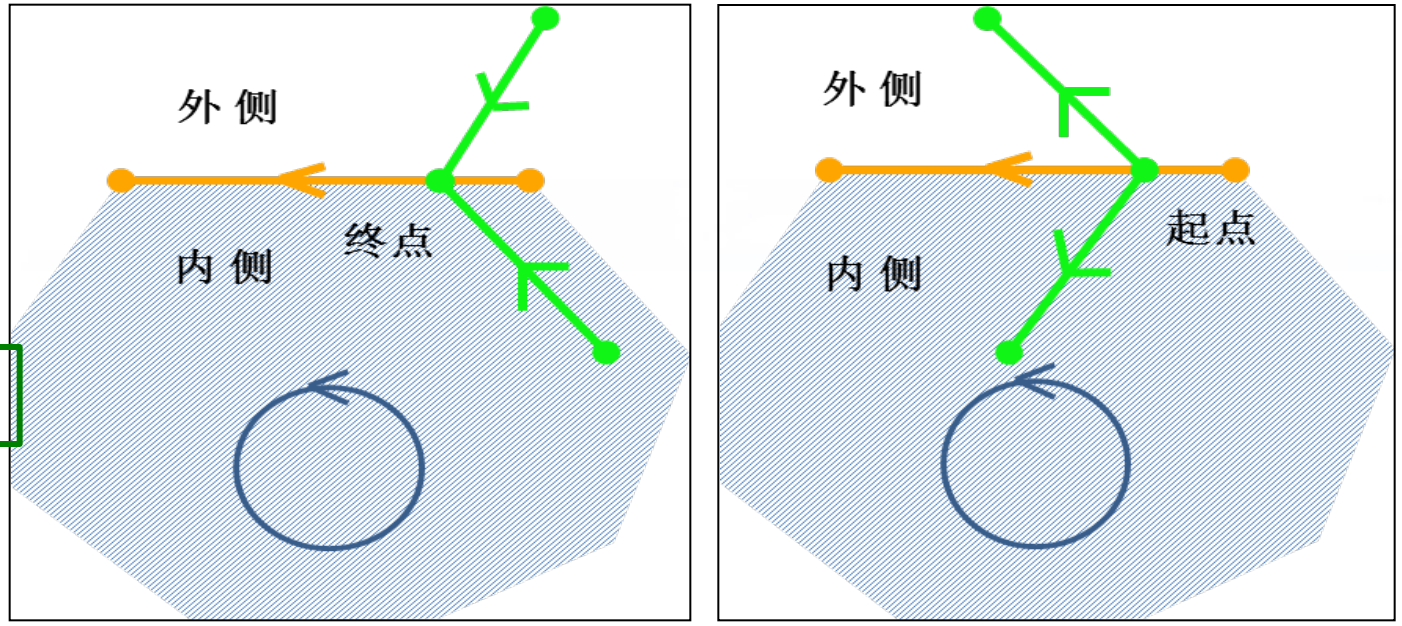
4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

2 faces relations reasoning operator

operator3

2D space

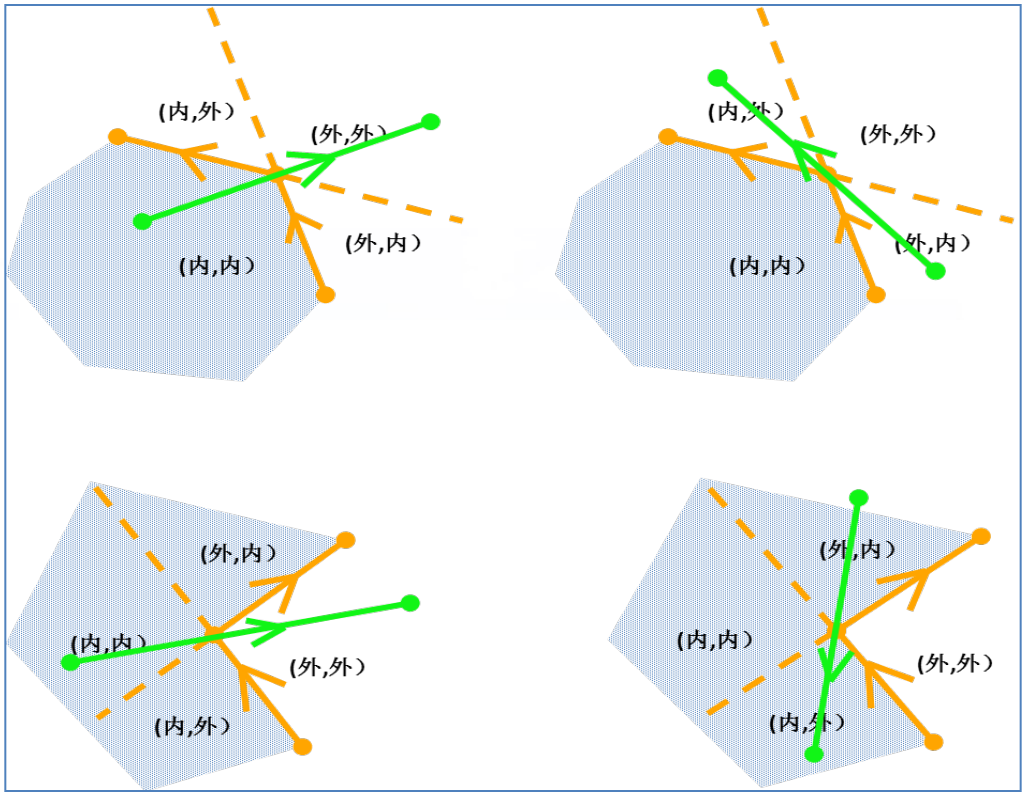


4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

2 faces relations reasoning operator

operator4



2D space

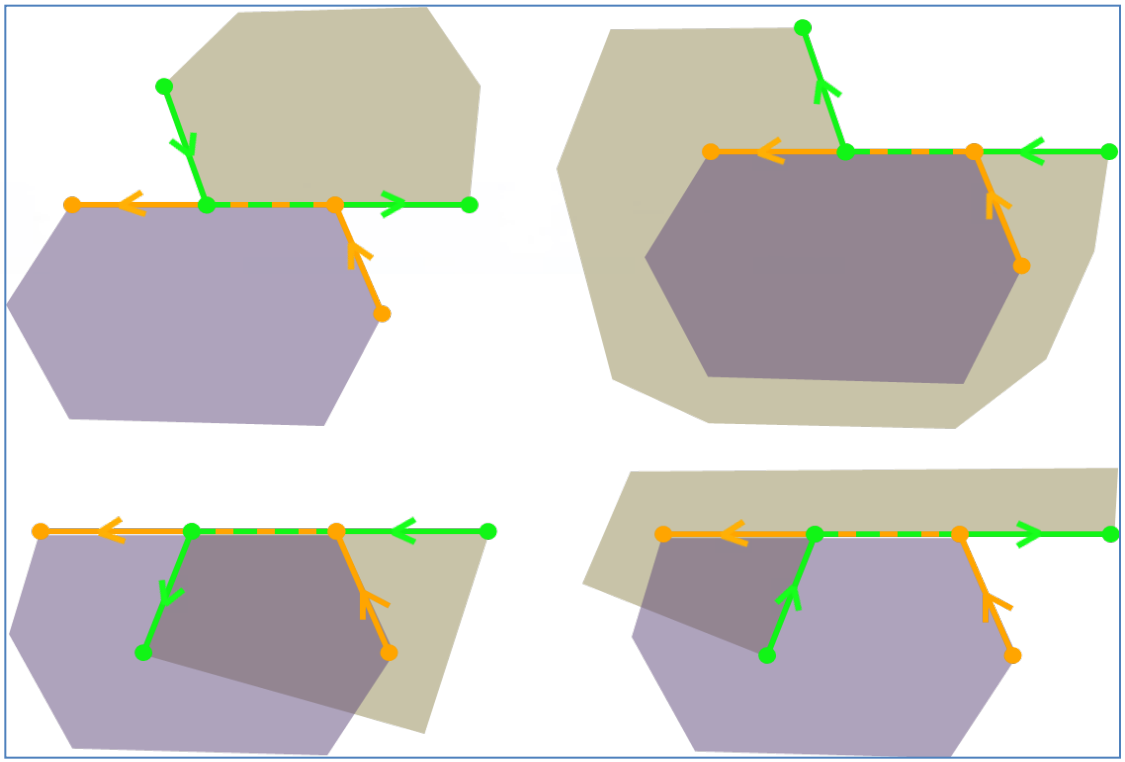
4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

2 faces relations reasoning operator

operator5

2D space

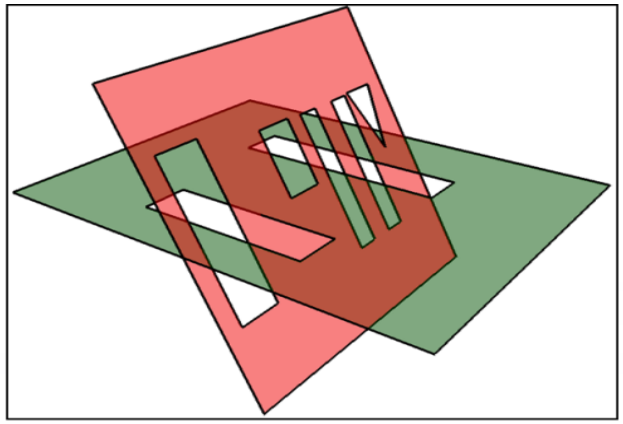


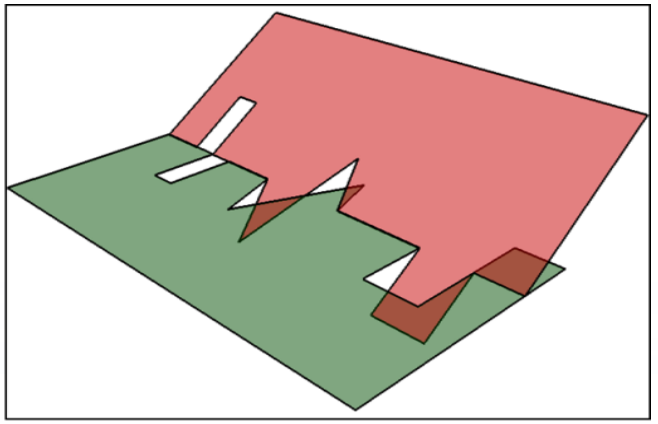
4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

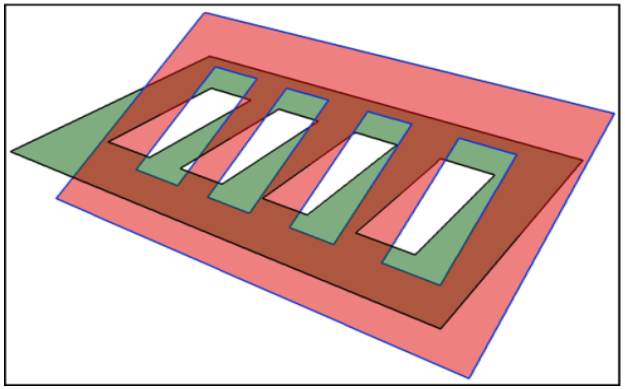
The algorithm design : several core Difficulties

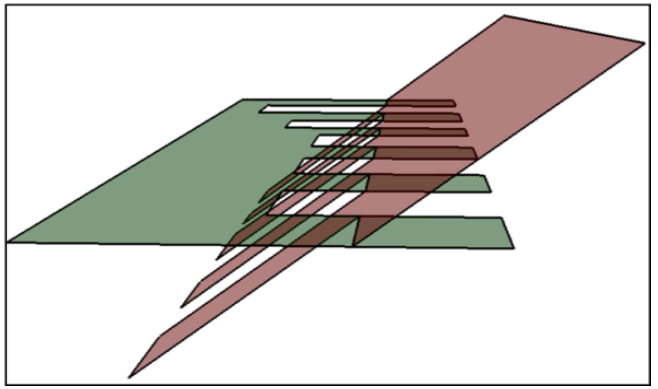
2 faces relations reasoning - pure computational geometry

3D space







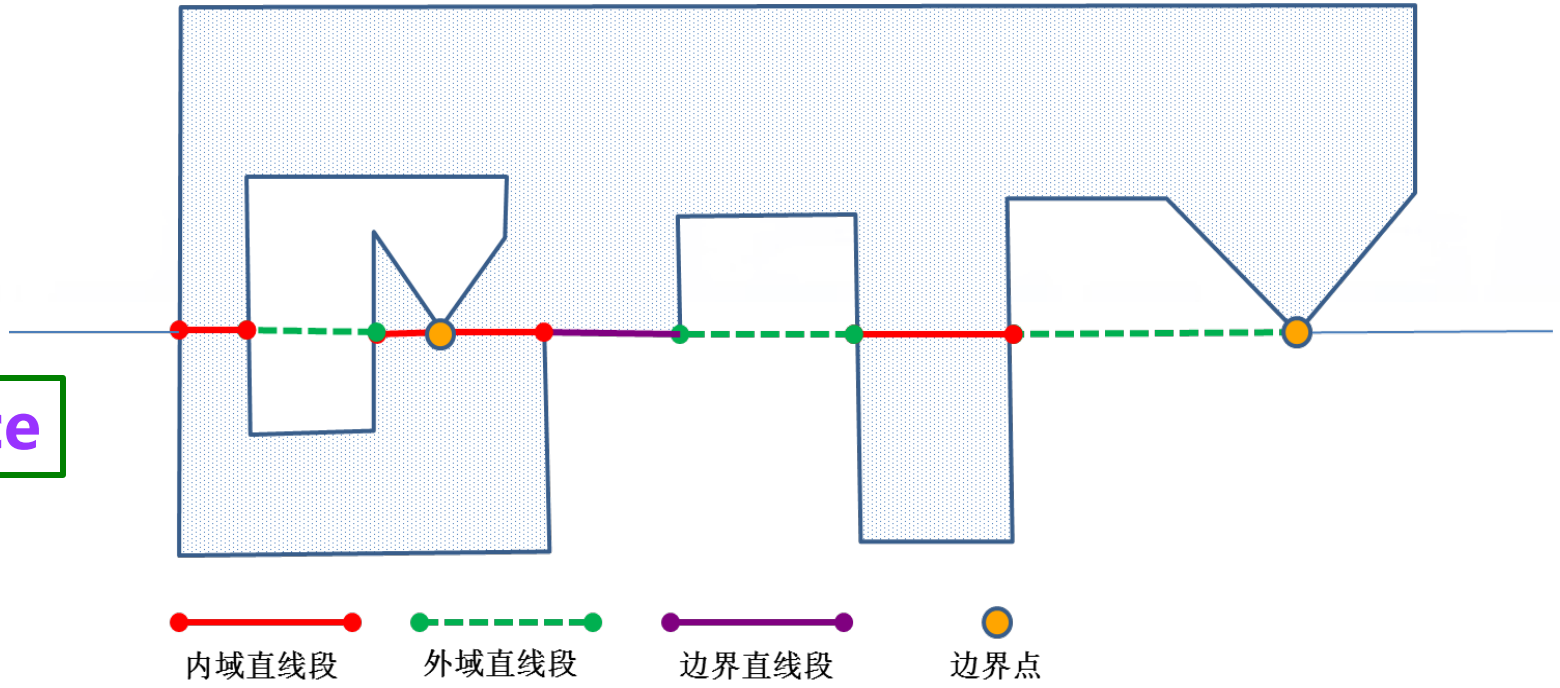


4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

2 faces relations reasoning - pure geometric computing

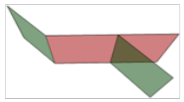
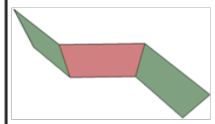
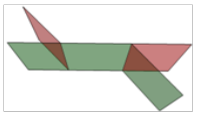
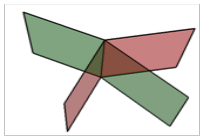
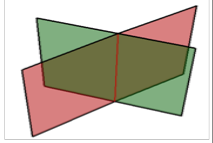
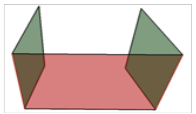
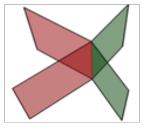
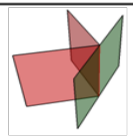
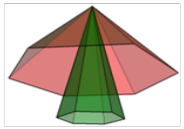
3D space



4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

4 bodies relations

两个表面交叠于二维 交叠	交叠1	交叠2	交叠3	交叠4
				
	FF5 FF6	FF2 FF3 FF6	FF1 FF3	FF4 FF6
两个表面交错于一维 交错	交错1	交错2	交错3	
				
	FF3	FF6	FF7	
两个表面重叠于二维 重叠	重叠1	重叠2	重叠3	重叠4
				
	FF5 FF6	FF2 FF3 FF6	FF1 FF3	FF4 FF6
两个表面相切于一维和零维 相切	相切1	相切2	相切3	
				
	FF3	FF6		

Identify Surface local relations

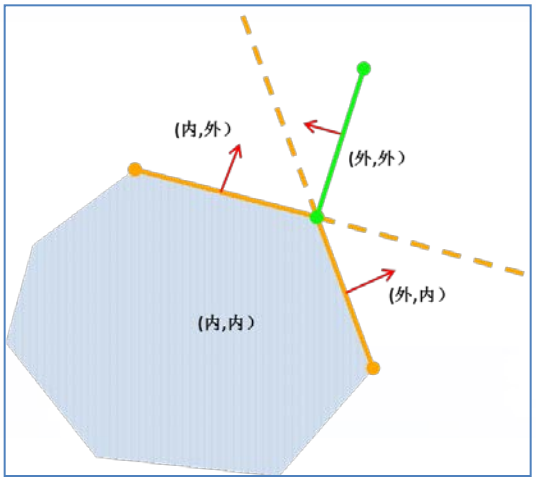
Local relations combination

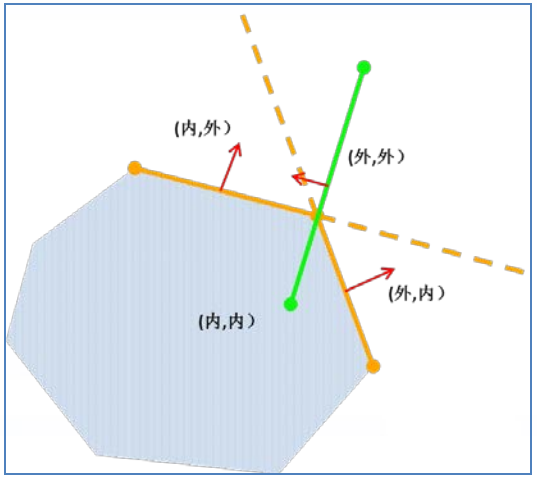
Bodies relation reasoning

4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

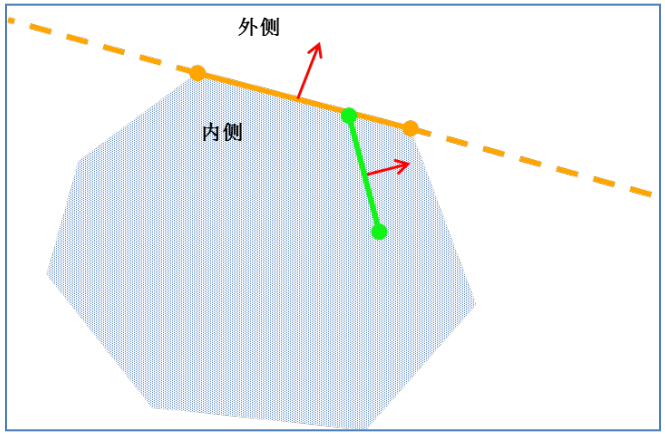
The algorithm design : several core Difficulties

4 bodies relations reasoning operator





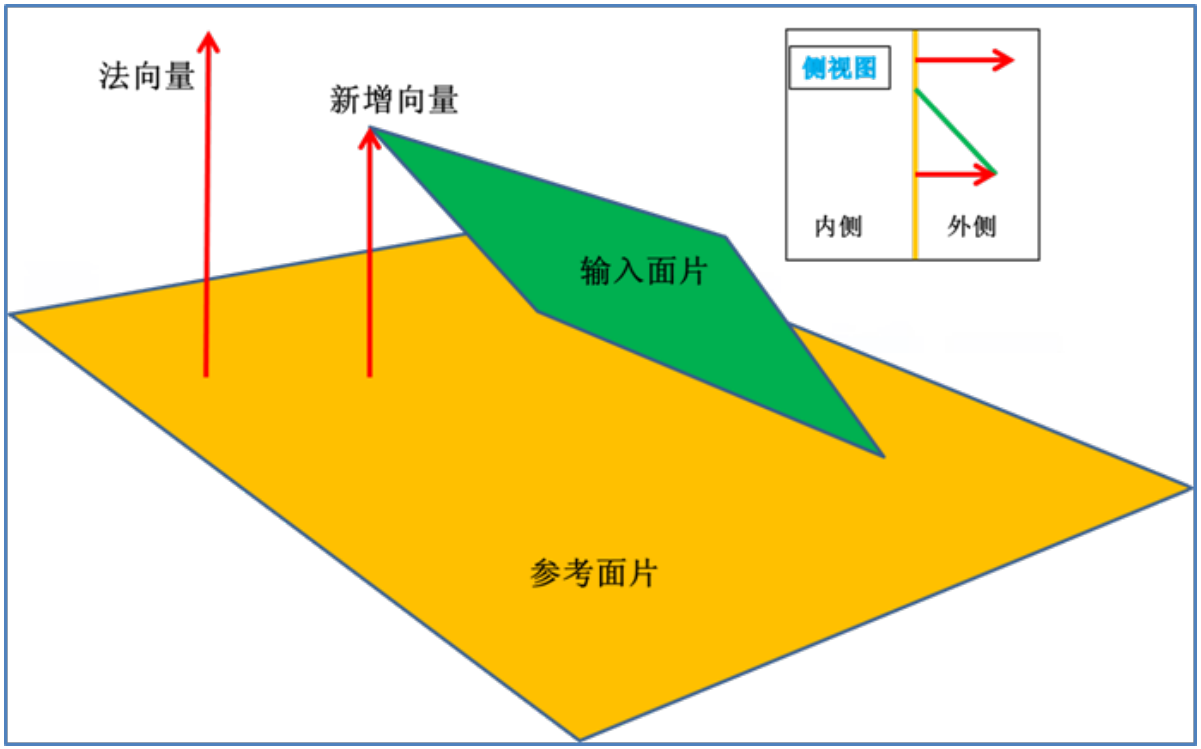
three operators



4 IDENTIFICATION OF TOPOLOGICAL RELATIONS

The algorithm design : several core Difficulties

3 bodies relation—vector angle judgment method



3 CONCLUSION

The algorithm in this paper can identify correct and incorrect topological relations among bodies. Therefore it could be used as topology checking module of a 3D cadastre management system. The algorithm has two main design purposes:

1) resolving the 3-dimensional parcel conflict and guarantee its unique and exclusive legitimate space;

2) correct topological relations represented in the underlying topological data structure and stored in a database could be the basis for the following spatial analysis.

THAT'S ALL! THANKS