Prism Model: Alternative 3D Spatial Model with Simplicity and Efficiency

Joon-Seok Kim, Ki-Joune Li
Department of Computer Engineering
Pusan National University, S. Korea

Spatial DB ✓

Introduction

- Motivation
  - With the recent increase of demands for 3D information, a simple and efficient data model for 3D spatial objects is required
  - In order to store, retrieve and transfer 3D data
- Prism model
  - Simple and efficient 3D spatial data model
  - Supporting spatial query

GML(B-Rep)	+	KML
Strong expressive power		Weak expressive power
Complex, large size of data		Simple, small size of data

Prism Model
Enough expressive power
Simple, small size of data

Fig1. Motivation of Prism Model

Concepts of Prism Model

- A pair of constraint geometries as boundaries
  - Lower geometry
  - Upper geometry
  - Same footprints

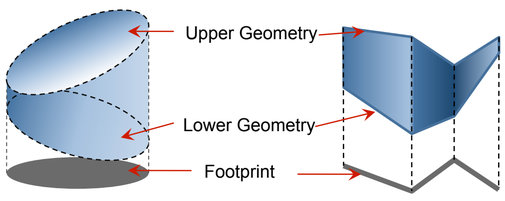


Fig2. Examples of Prism model

- Constraints of Extrusive Polygon
  - Same 2D footprints and the sequences of vertices
  - Each height of vertices should be
    - $h_n \le h'_n$

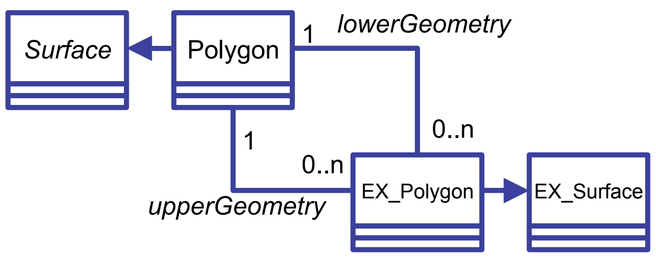


Fig3. Schema of Extrusive Polygon

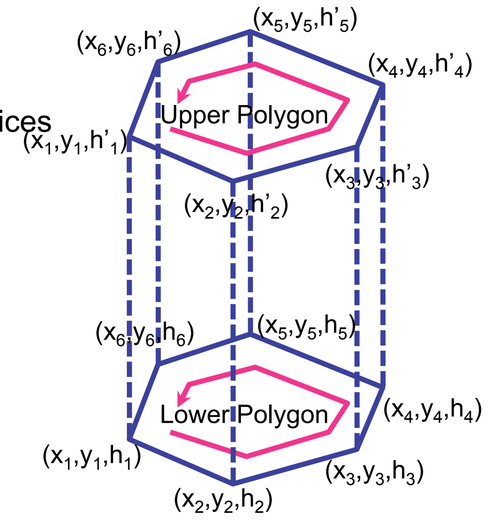
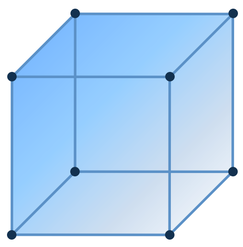


Fig4. Schema of Extrusive Polygon

Comparison Analysis

- Data size
  - The prism model contains less geometric component than the B-Rep model



GML	Prism
8 vertices	8 vertices
12 lines	8 lines
6 faces	2 faces

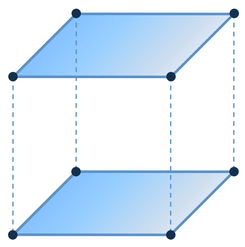
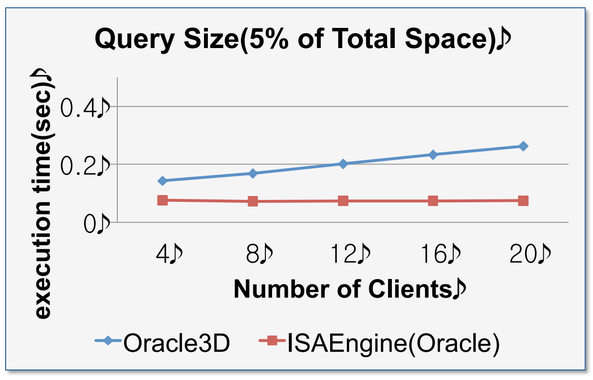


Fig10. Comparative Dataset size of GML and Prism

- Experiments
  - Dataset: KINTEX Convention Center (South Korea)



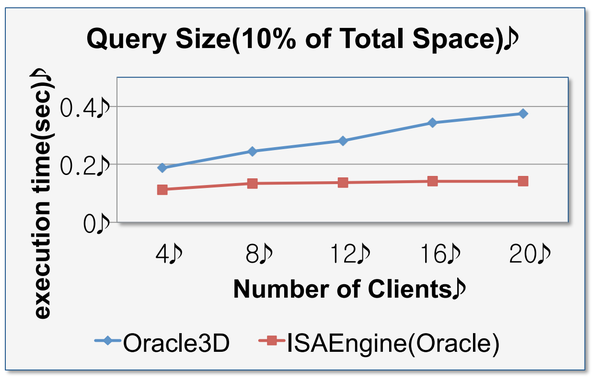
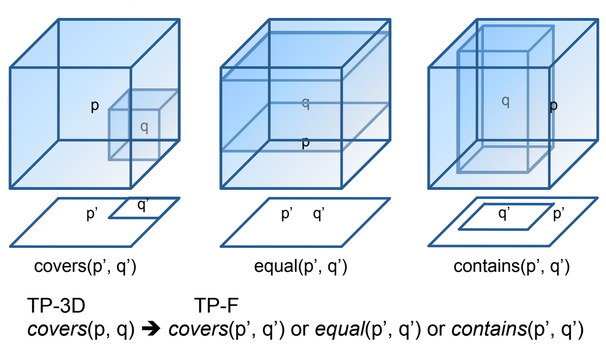


Fig11. Comparison of Performance between B-Rep and Prism

Spatial Query Processing

- Topology of 3D object (TP-3D) can be derived from
  - Topology of 2D Footprint (TP-F)
  - Topology of Elevation (TP-E)
  - Using decision DAG



TP-3D *covers*(p, q) ➔ TP-F *covers*(p', q') or *equal*(p', q') or *contains*(p', q')

Fig5. Example of TP-3D: Cover

TP-3D \ TP-F	e	i	ct	cv	cb	o	m	d
e	1	0	0	0	0	0	0	0
i	0	1	0	0	0	0	0	0
ct	0	0	1	0	0	0	0	0
cv	1	0	1	1	0	0	0	0
cb	1	1	0	0	1	0	0	0
o	1	1	1	1	1	1	0	0
m	1	1	1	1	1	1	1	0
d	1	1	1	1	1	1	1	1

e : equal
i : inside
ct : contains
cv : covers
cb : covered by
o : overlap
m : meet
d : disjoint

0 : impossible
1 : possible

Fig6. Relationships between TP-F and TP-3D

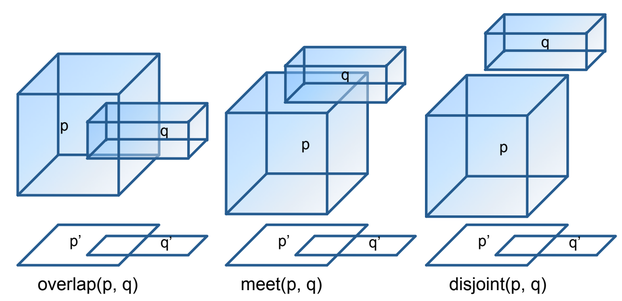


Fig7. Example of TP-E: Overlap

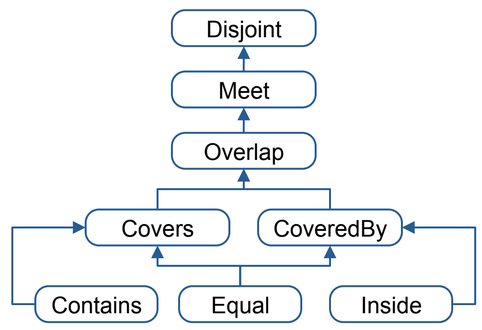


Fig8. Decision DAG for TP-3D

- Query processing using legacy 2D spatial DBMS
  - We apply the 2D filtering technique to process 3D spatial queries, which is a co mmon query processing policy for 2D spatial databases.

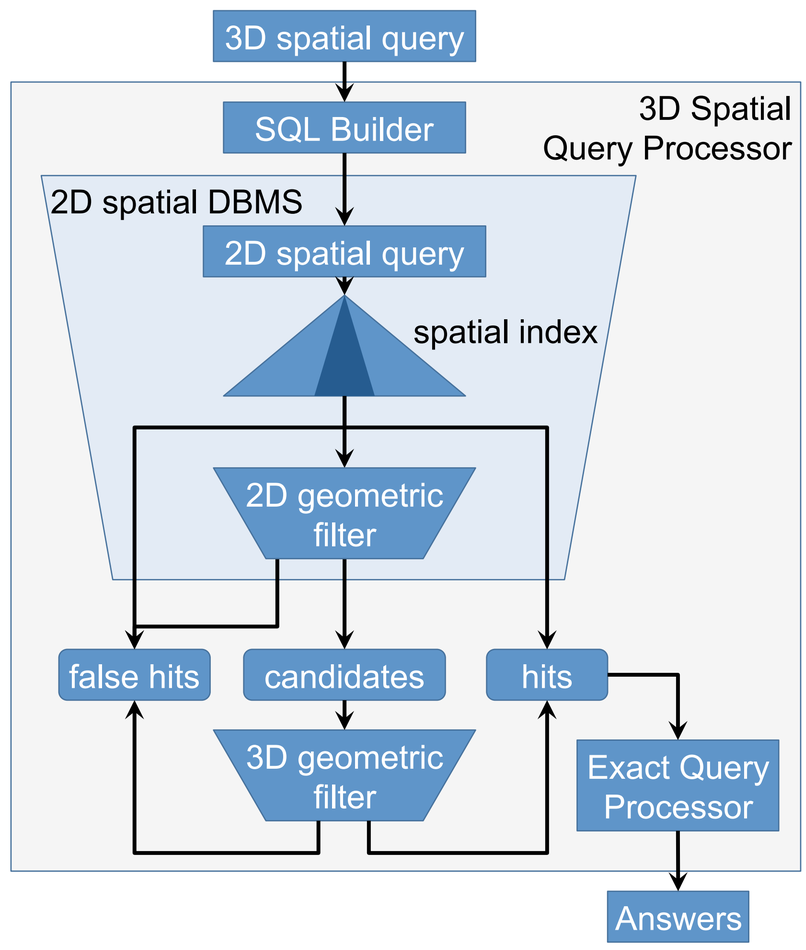


Fig9. Process of Spatial Query Processing using 2D spatial DBMS

Conclusion

- Prism model
  - An alternative and simple 3D spatial model
  - Based on extrusion technique from the footprint
- Topology of Prism Model
  - Topology of 2D Footprints
  - Topology of Elevations
- 3D Topological Operator
  - Reusing the 2D spatial DBMS
  - Simple and efficient algorithm

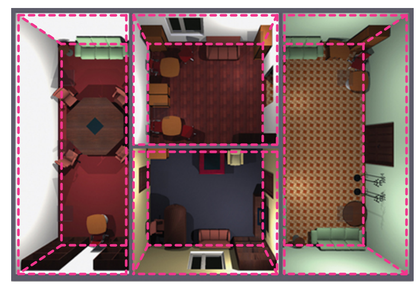


Fig12. Application of Prism Model: Indoor Space