

# **Construction operators for modelling 3D objects and dual navigation structures**

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**EPSRC** Engineering and Physical Sciences  
Research Council

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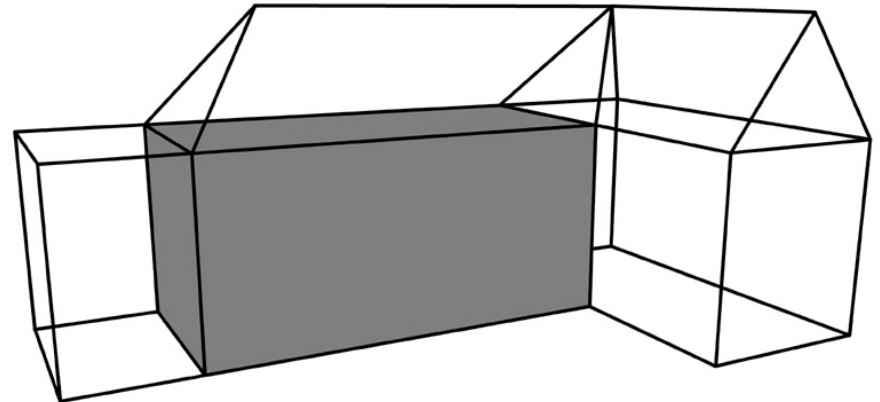
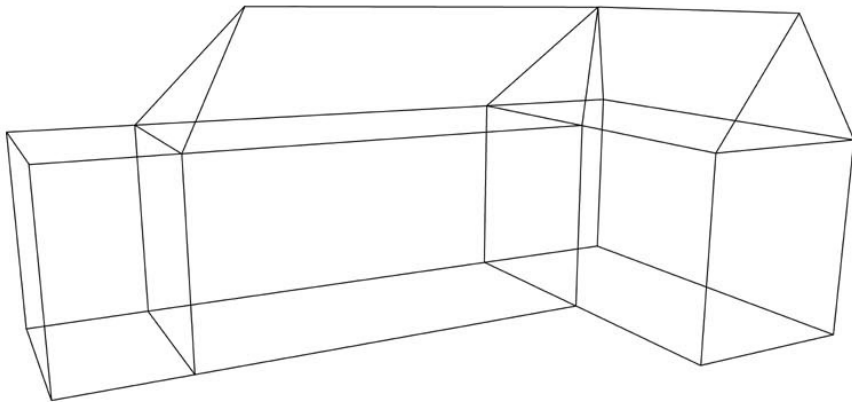
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- Traditional CAD and b-rep models
- Building interiors and emergency management
- The Quad-Edge and Augmented Quad-Edge structures
- Atomic construction operators
- Dual Half Edge and Euler operators – latest work
- Applications
- Conclusions

# Traditional CAD and b-rep models

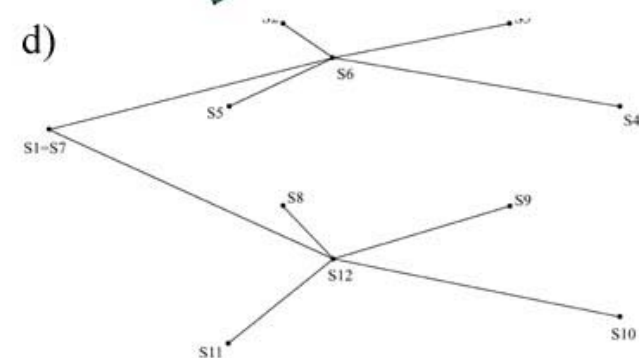
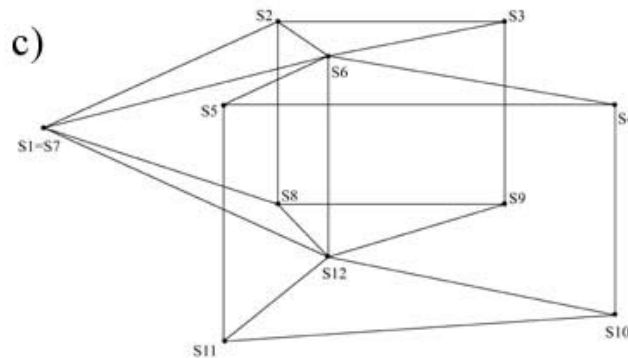
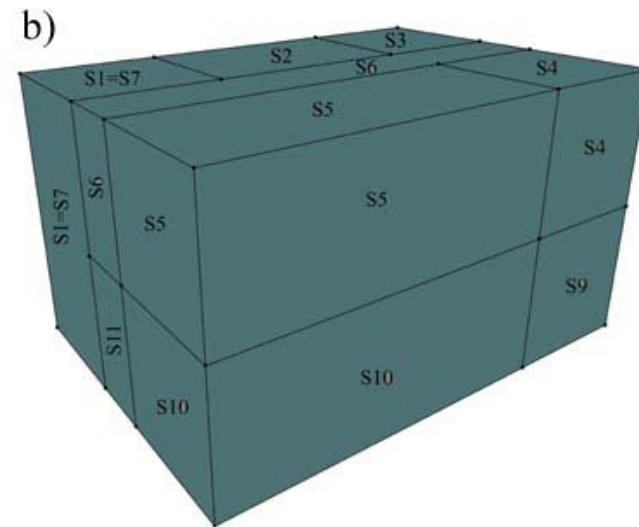
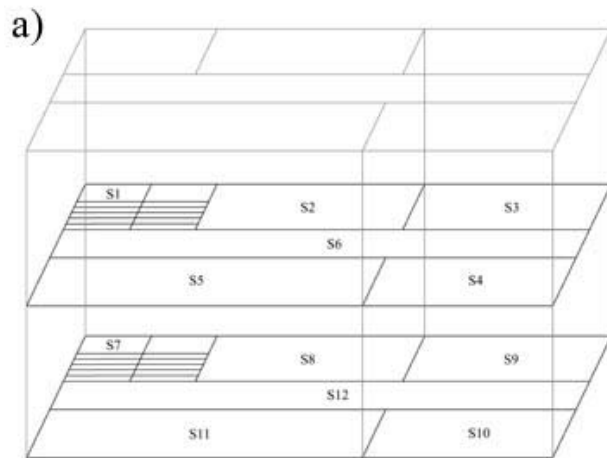
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- People often use CAD systems with boundary representation models
- Our new model has volume elements as well as boundaries



# Building interiors and emergency management

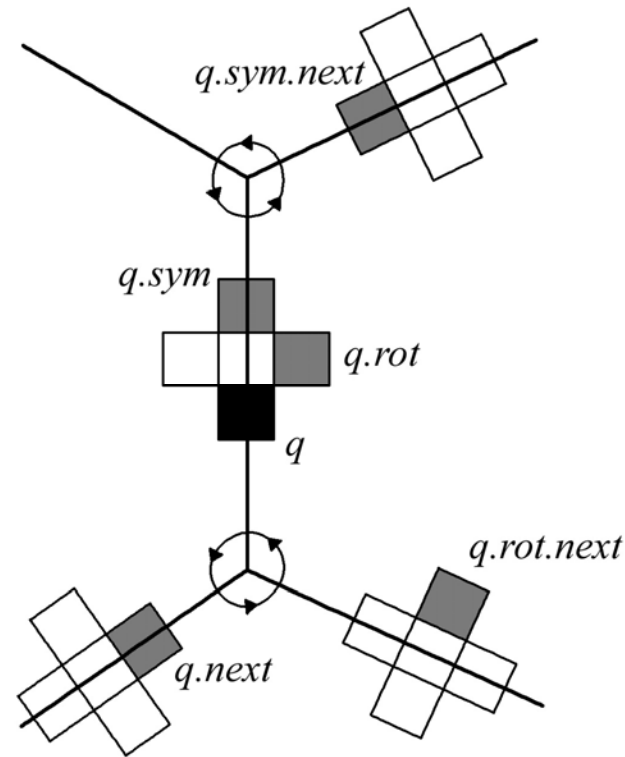
- Duality
- Dynamic changes for escape routes



# Structures – traditional Quad-Edge (QE)

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- 3 pointers
  - R
  - N
  - V
- navigation
  - Rot
  - Next
  - Sym
- construction
  - MakeEdge
  - Splice

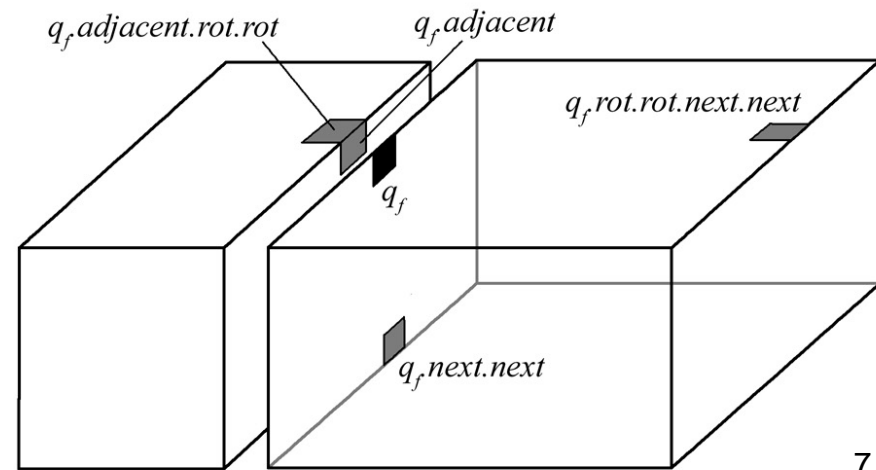
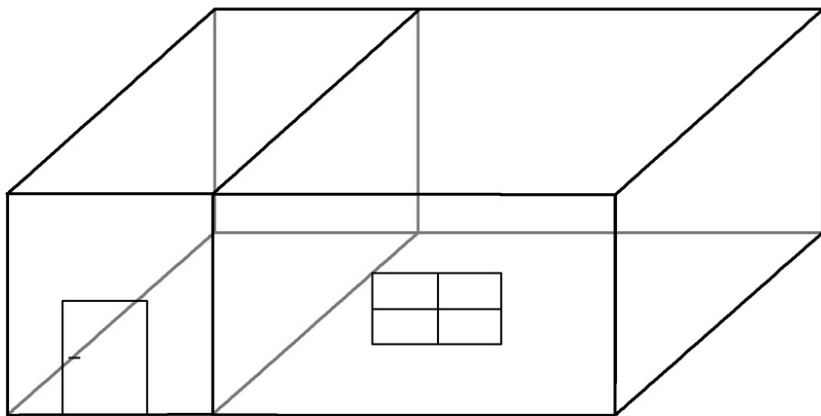


- May be used for b-rep

# Structures – Augmented Quad-Edge (AQE)

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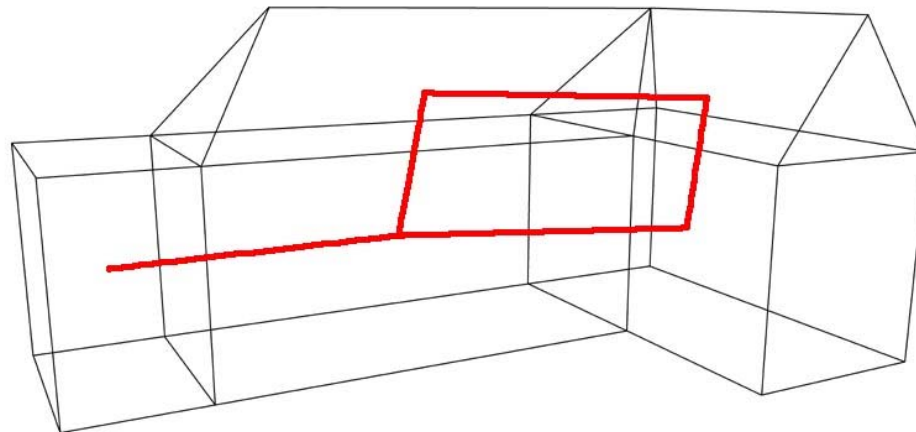
- Extension of the Quad Edge structure
- Pointer based navigation
- Through pointer using dual
- Adjacent operator
- Volume elements



# Construction operators (AQE)

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- In previous work the construction was the most difficult issue
- Our objective is a simultaneous and automatic construction of two graphs: Primal – “geometry” and Dual – “topology”



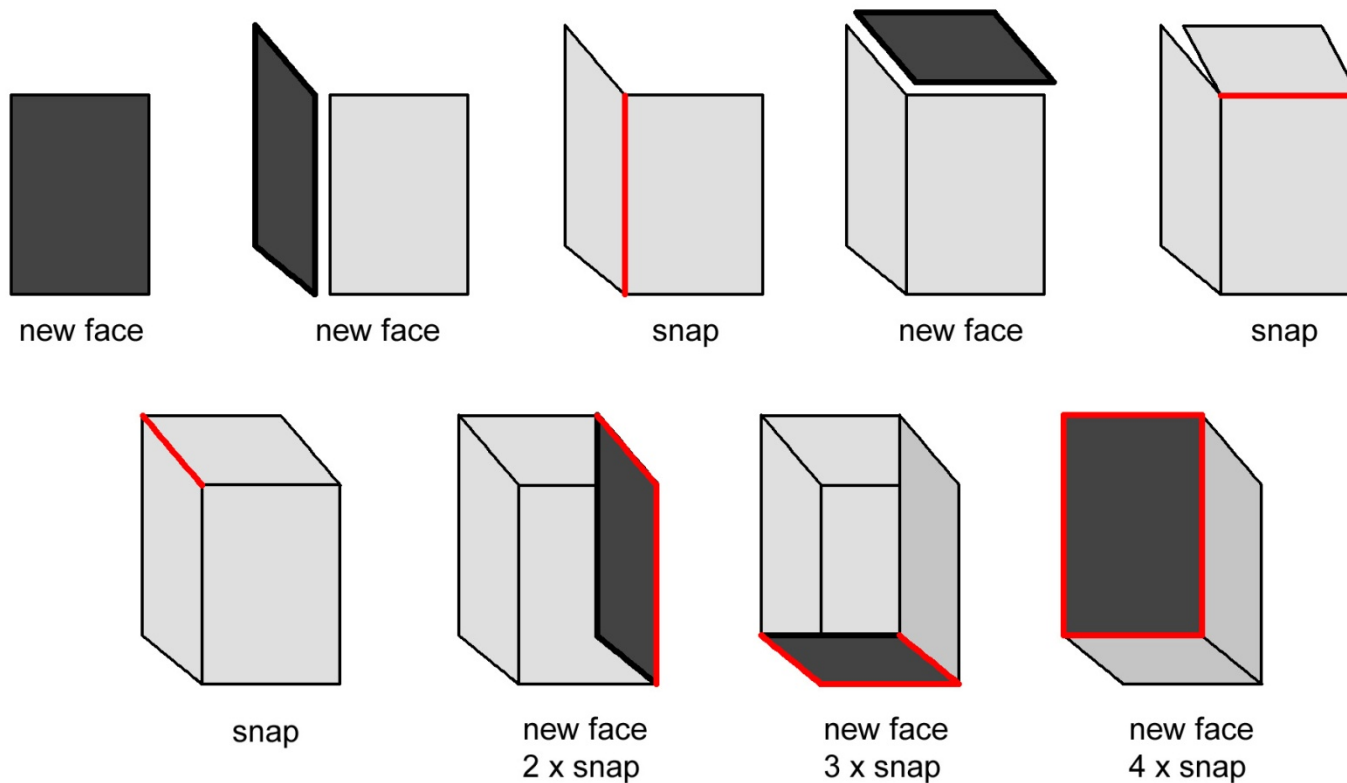


# Construction operators (AQE)

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## “Cardboard & Tape” - simple construction of 3D objects

– (MakeFace/KillFace and SnapFaces operators)



# Structures – latest work

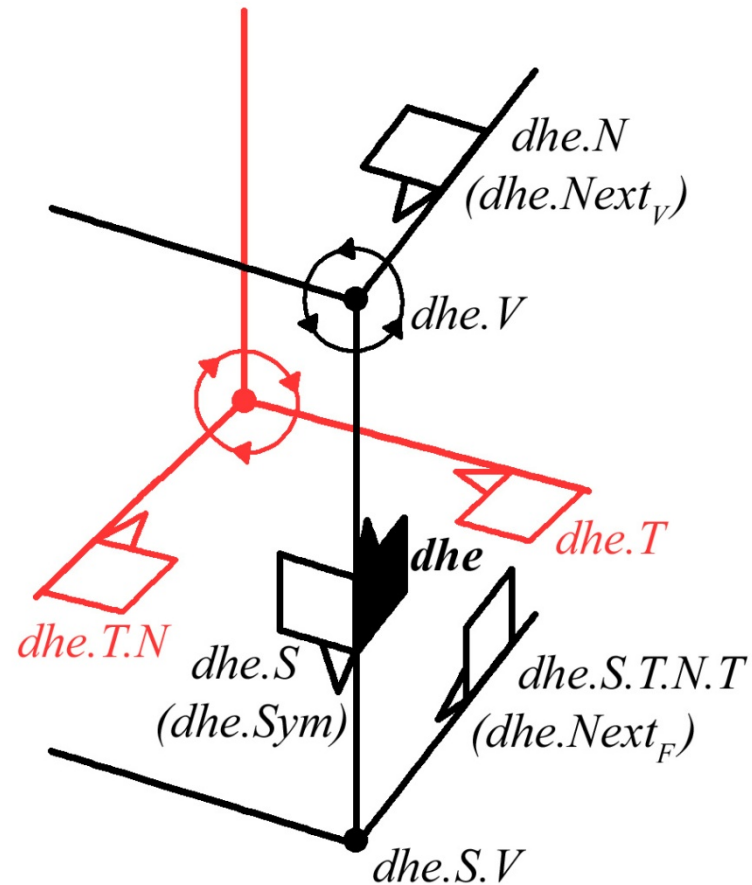
## New data structure - Dual Half Edge (DHE)

### Pointers

- N (next edge around a vertex)
- S (the second half of an edge)
- T (dual edge)
- V (vertex)

### Navigation

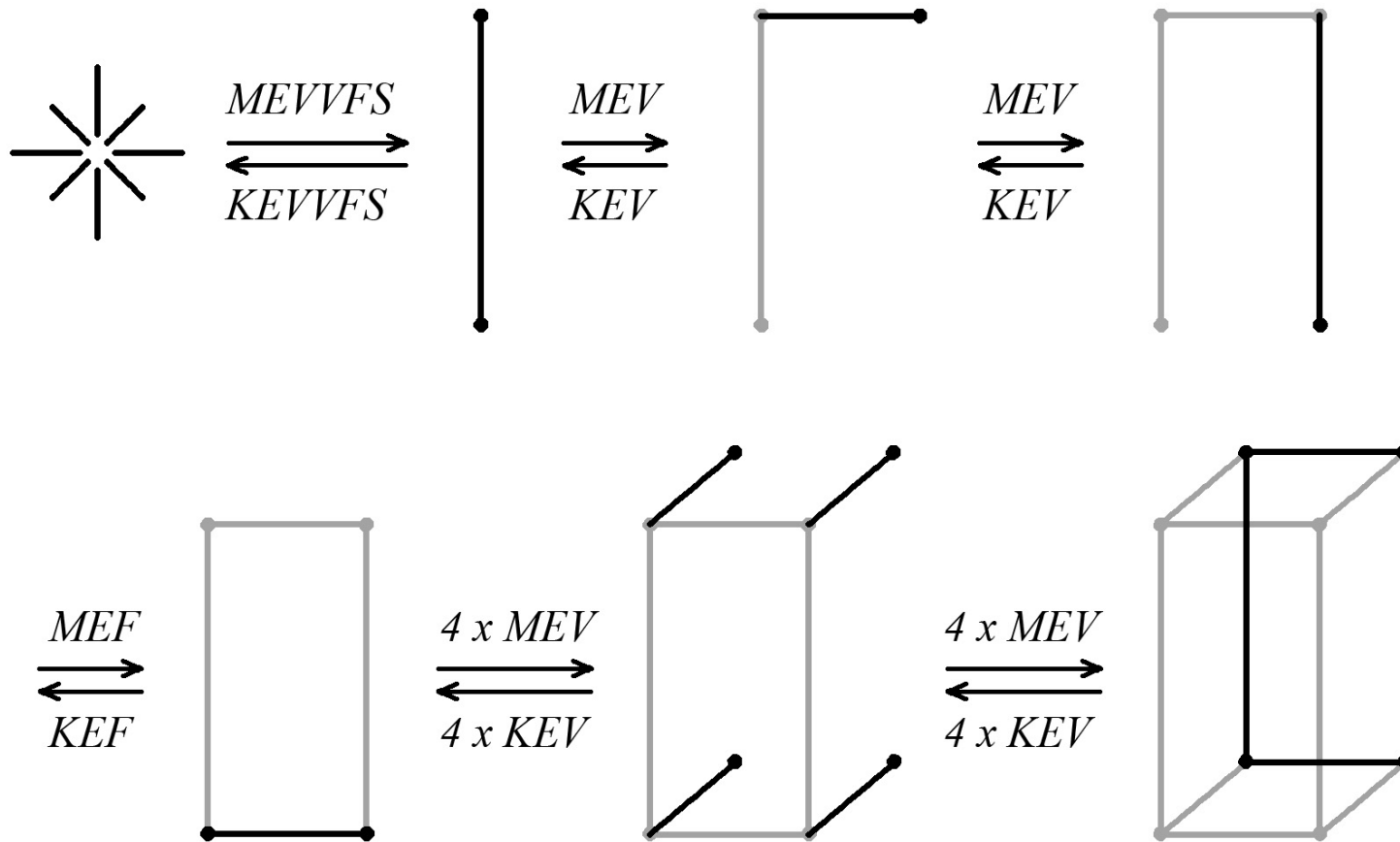
- Sym (he.S)
- Next<sub>F</sub> (he.S.T.N.T)
- Next<sub>V</sub> (he.N)
- Through (he.T)
- Adjacent (he.T.S.T.N.S)



# Construction operators - latest work

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## Set of Euler operators using DHE



# Construction operators - latest work

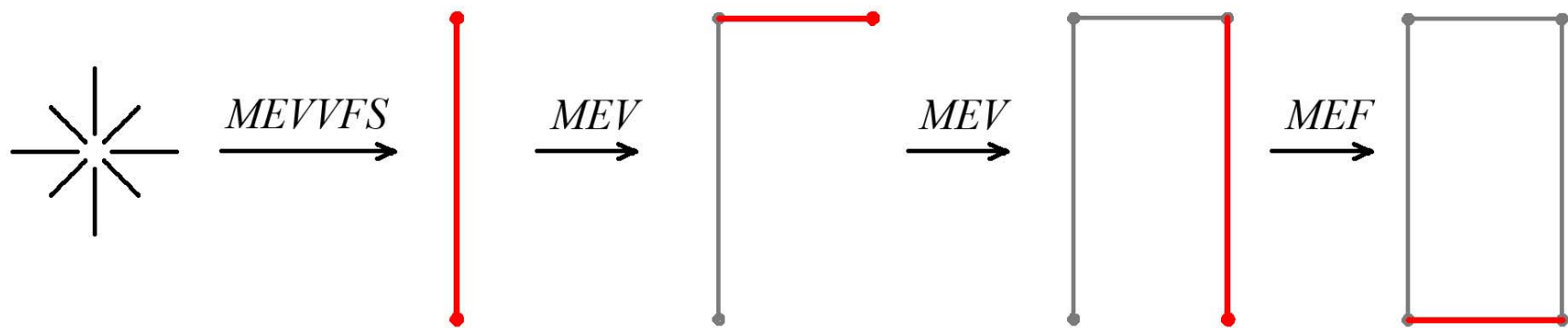
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- Euler operators are now used to create “cardboard & tape” models
- This now conforms to traditional CAD, but with automatic dual
- Primal and dual are constructed simultaneously in each step

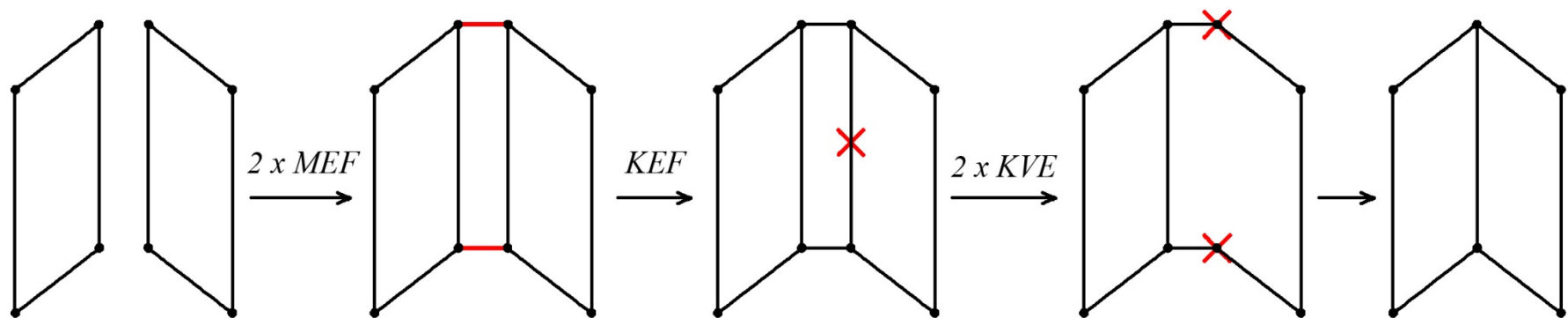
# Construction operators - latest work

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## Step 1. Create faces



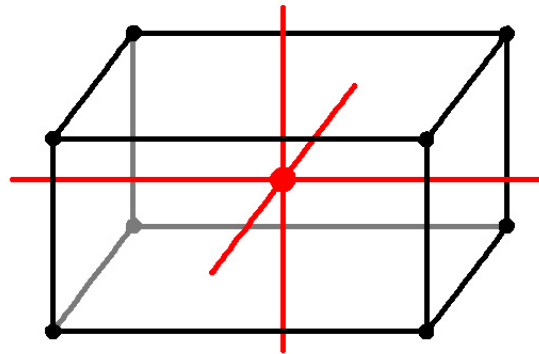
## Step 2. Snap neighbour faces



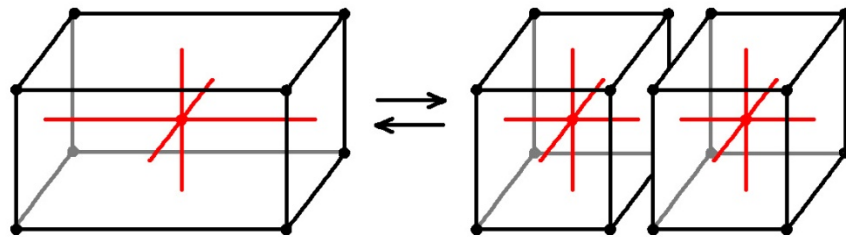
# Construction operators - latest work

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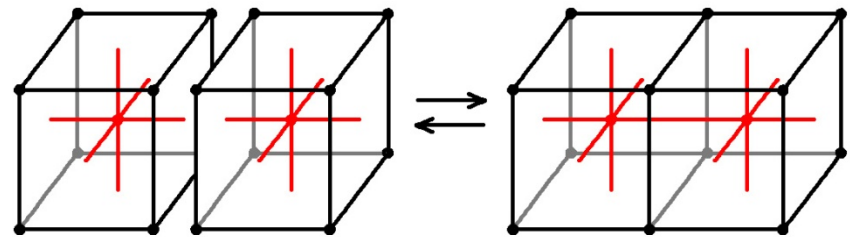
Step 3. Calculate dual point for a new cell



Other operators in a cell complex



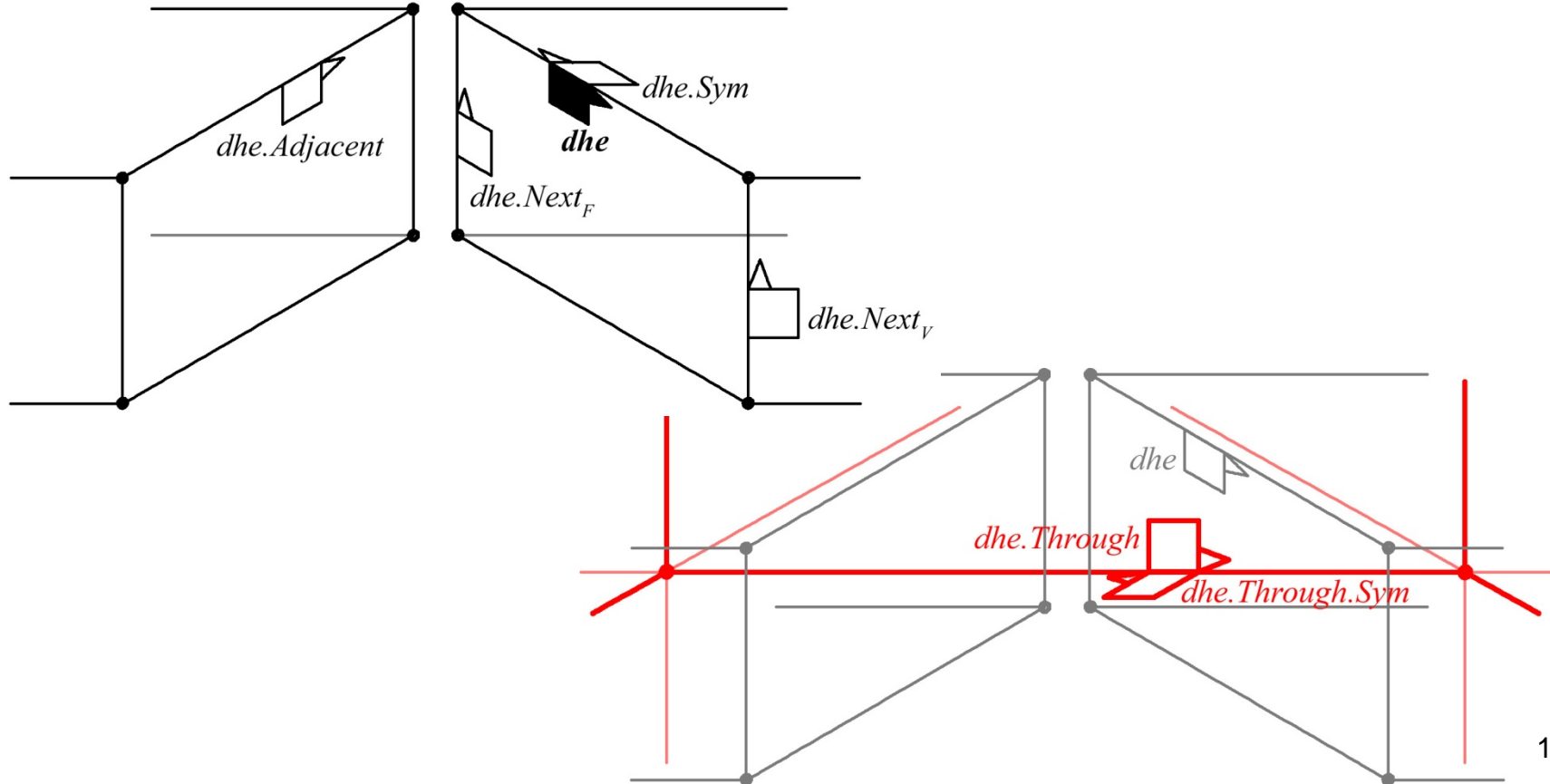
*Split/Merge*



*Connect/Disconnect*

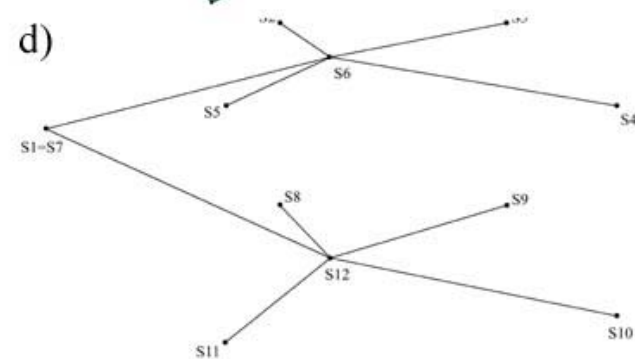
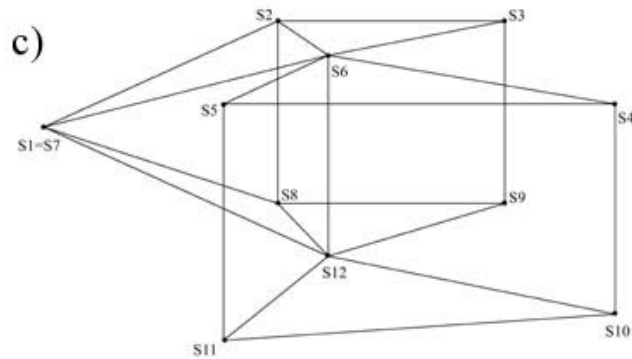
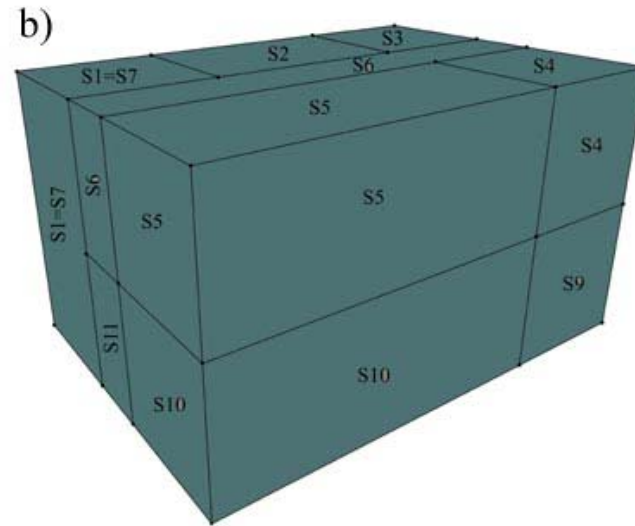
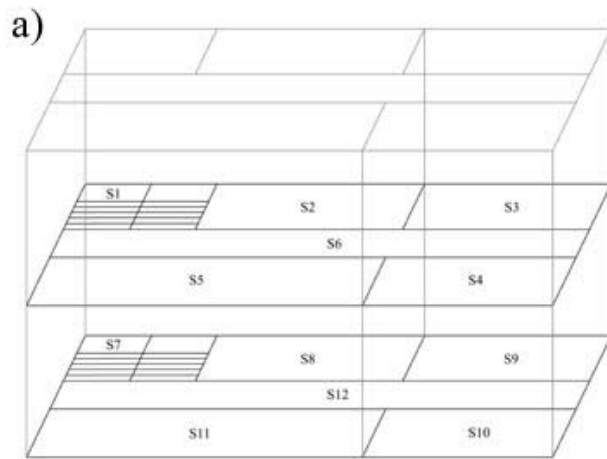
# Navigation - latest work

- Edge algebra
- Navigation from edge to edge using pointers



# Applications

Models of buildings interiors – e.g. emergency management systems

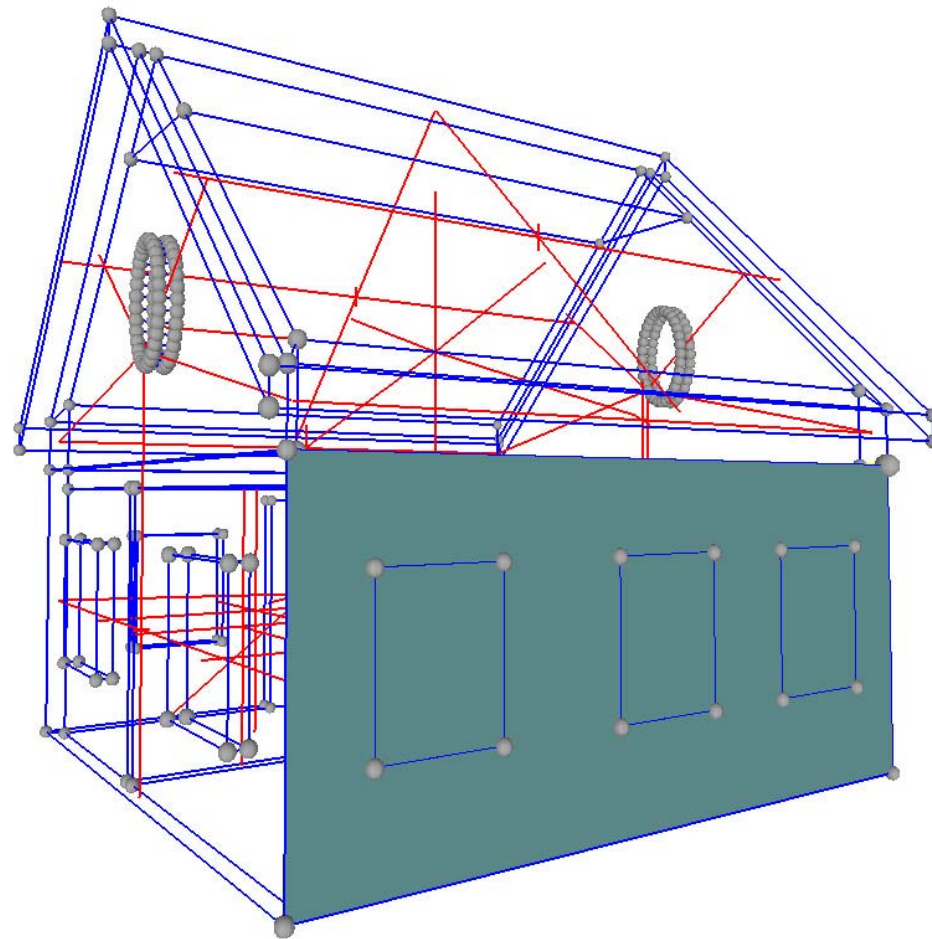




# Applications – current work

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Import **GML** format and automatic construction of models



# Properties and Conclusions

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- We have a preliminary data structure and set of construction operators for primal/dual navigation and simultaneous construction
- Associated edges in the primal and dual space are linked together permanently (Through pointer doesn't need to be changed)
- Euler operators conform to CAD

# Demo

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Start

# Thank you

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