程序代写代做 CS编程辅导

CMT1[illegible]ual Computing

III.2 Scene Representation

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Overview

- Hierarchical modelling
  - Scene graphs
  - Constructing graphs
- Spatial data structures
  - Uniform grids
  - Octrees
  - kD-trees
  - BSP-trees
- Multi-resolution models

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Hierarchical Modelling

- A scene is the complete description of the environment
  - A view is a particular part of the scene visible from the camera position
  - A scene consists of many models, only some are visible
- A scene can be represented by a hierarchical structure
  - A node represents some part of the scene
  - Top node is the whole scene
  - Leaf nodes are the actual geometric models
- Objects specified in *local coordinates*
  - Add transformation to hierarchy to specify location in scene

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Scene Tree Example

- Scene tree for a simple car

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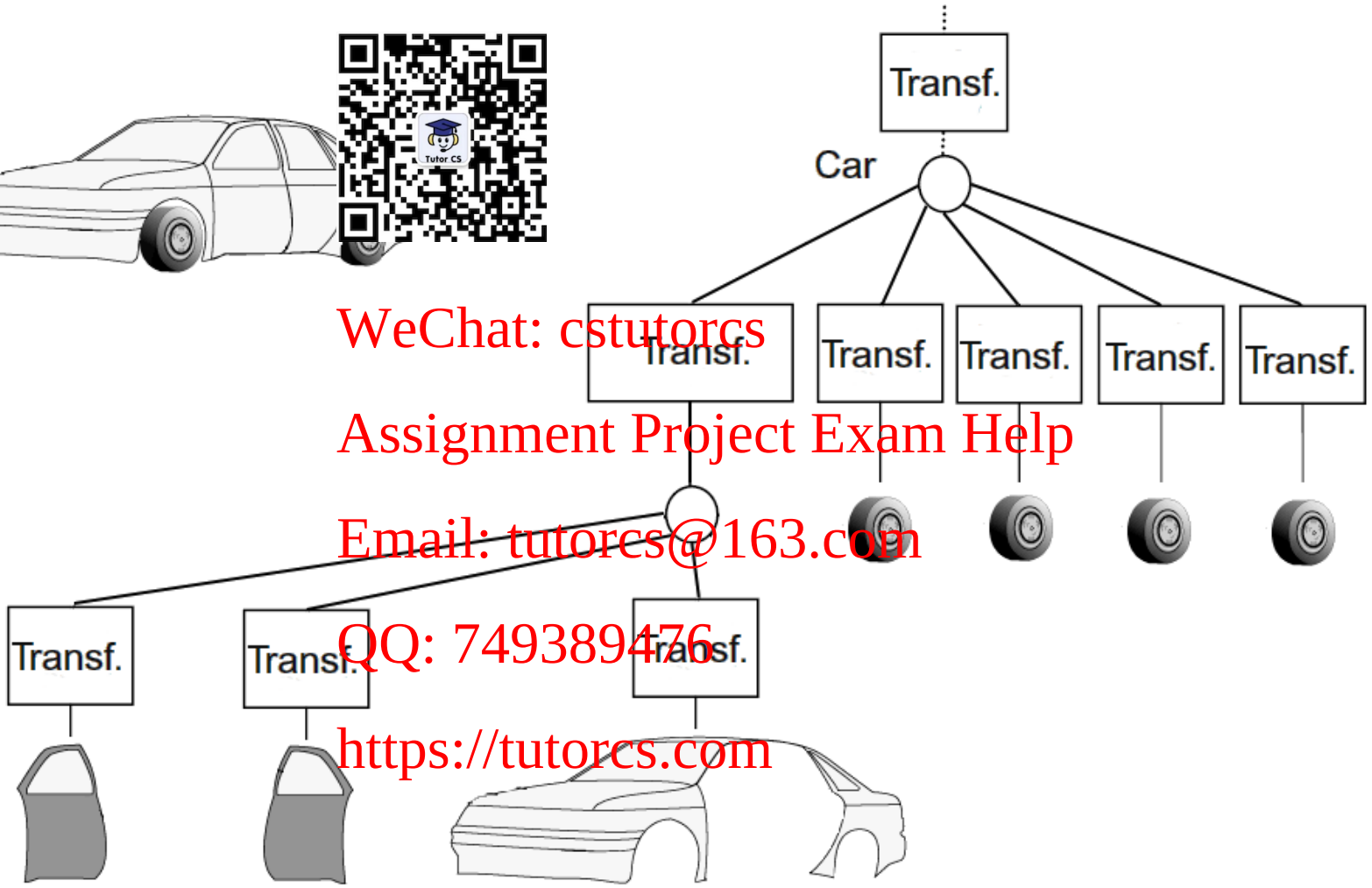

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Scene Graph Example

- Scene graph: combine congruent objects

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Scene Graphs

- Scene Graphs are in general *directed acyclic graphs*
  - Explicitly represented by graph data structure
  - Or implicitly by sequence of instructions / function calls
- Attributes and inheritance
  - Graph may contain material, transformation, . . . nodes representing object attributes
  - Attributes are usually inherited by all sub-nodes
- Also suitable for animations:
  - Make transformations dependent on parameter, e.g. time, motion control parameters, . . .

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Robot Arm—OpenGL Implementation

```
T.initialize();
T.scale(0.5f, 0.5f, 0.5f);
T.scale(2f,0.4f,1f);
T.translate(1,0,0);
T.rotateA(-50f, -0.2f, 0f, 1f);
gl.glUniformMatrix4fv( ModelV
                       T.getTr                    );
gl.glUniformMatrix4fv( Normal                     true,
                       T.getIn                    (), 0 );
gl.glDrawElements(GL_TRIANGLES, numElements,
                        GL_UNSIGNED_INT, 0);

T.initialize();
T.scale(0.5f, 0.5f, 0.5f);
T.scale(1.5f,0.4f,1);
T.translate(0.75f,0,0);
T.rotateZ(50);
T.translate(2.00f, 0.0f, 0);
T.rotateA(-50f, -0.2f, 0f, 1f);
gl.glUniformMatrix4fv( ModelView, 1, true,
                       T.getTransformv(), 0 );
gl.glUniformMatrix4fv( NormalTransform, 1, true,
                        T.getInvTransformTv(), 0 );
gl.glDrawElements(GL_TRIANGLES, numElements,
                        GL_UNSIGNED_INT, 0);
```

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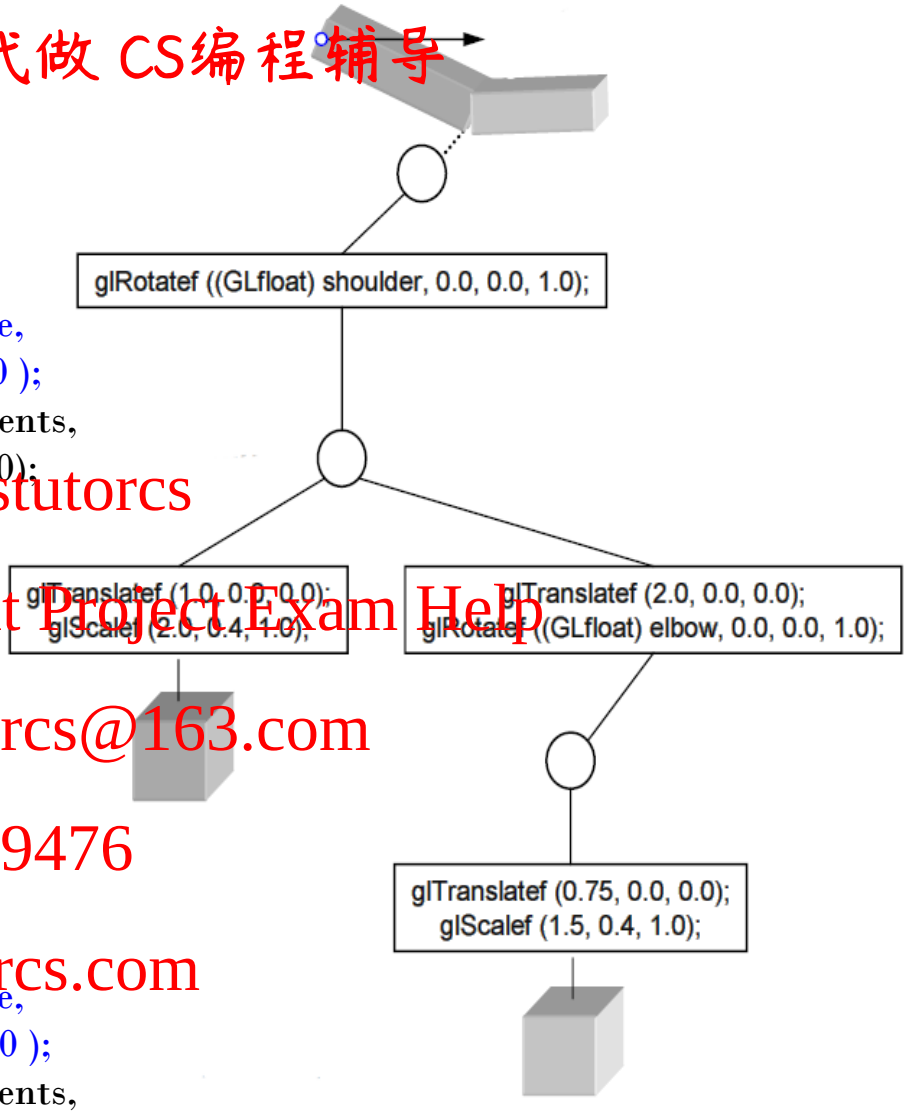

Hierarchy Construction

- Problem: find *optimal hierarchy* for scene graph
  - Choose bounding volumes
    spheres, boxes, hulls, . . .
  - Construct hierarchy of objects based on some heuristic
    (depends on application)
- Consider solutions for special cases
  - Spatial closeness of models
  - Standard spatial data structures

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Spatial Data Structures

- Represent *spatial relations* in scene graphs
  - Which models are visible from a camera position?
  - Which models can be accessed from a certain position?
  - With which models does a model collide?
  - . . .
- The more information about the spatial relations between models is known, the faster the scene can be processed
  - *Partition* space and place objects within subregions
  - Create *hierarchy* of spatially close models
  - Helps algorithms to determine relevant models quickly

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Example 3D Scene

- 3D scene example (ray-tracing)

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Uniform Grids

- Partition space *uniformly* using a 3D grid
  - 3D array of model lists

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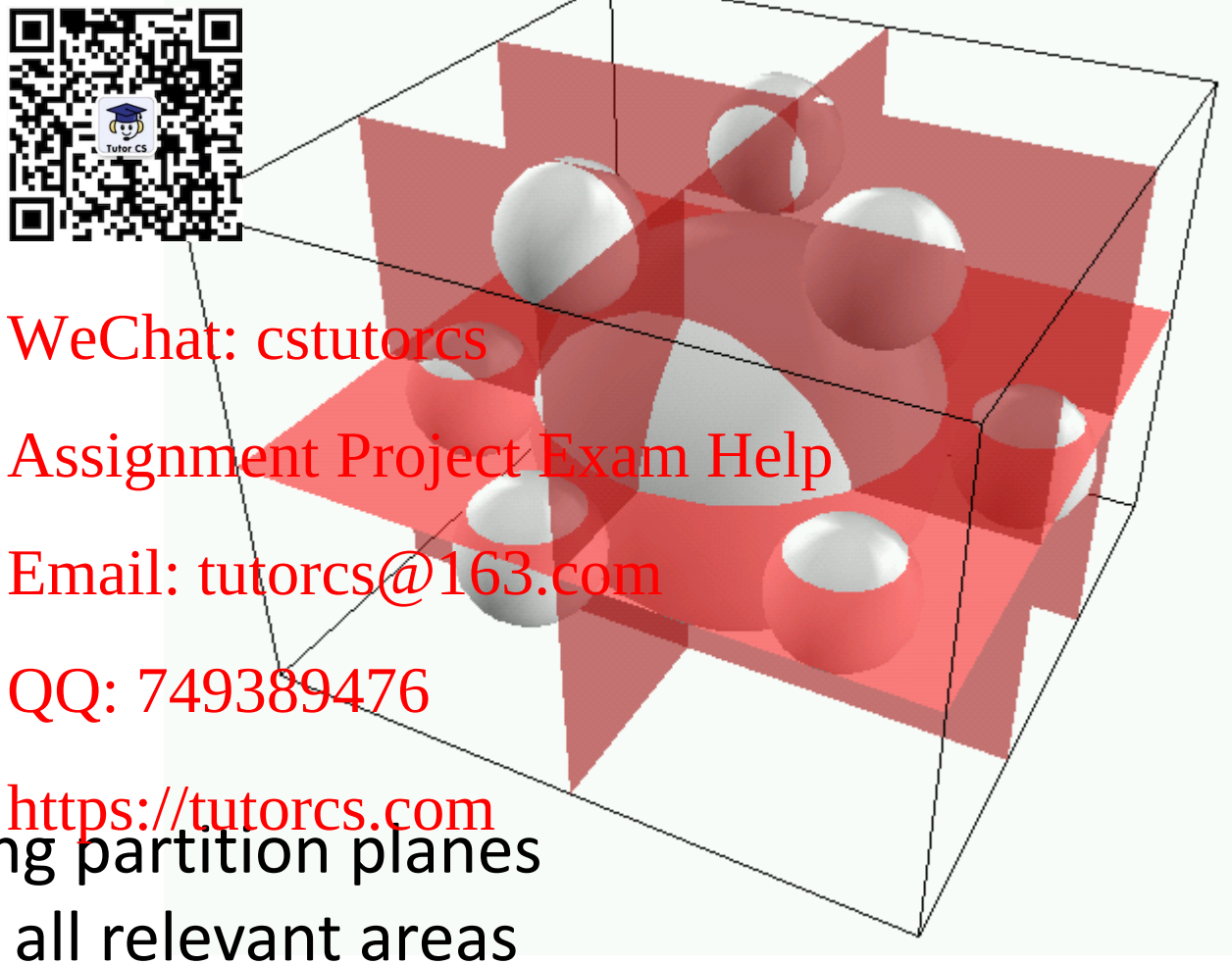

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  - Cut models along partition planes
  - Or add them to all relevant areas

Octrees

- Partition space using a 3D *hierarchical grid*
  - Tree with 8 children per node

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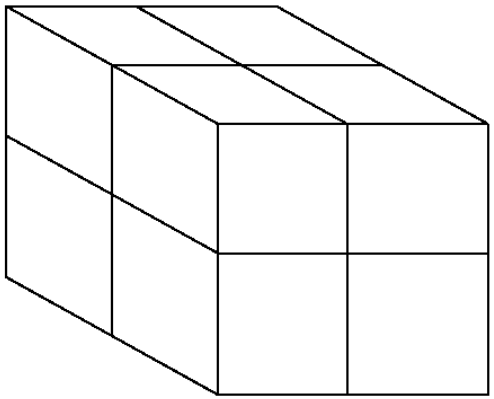

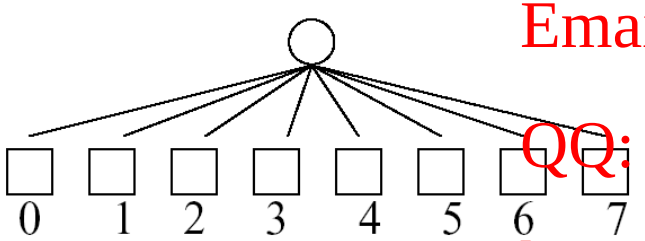

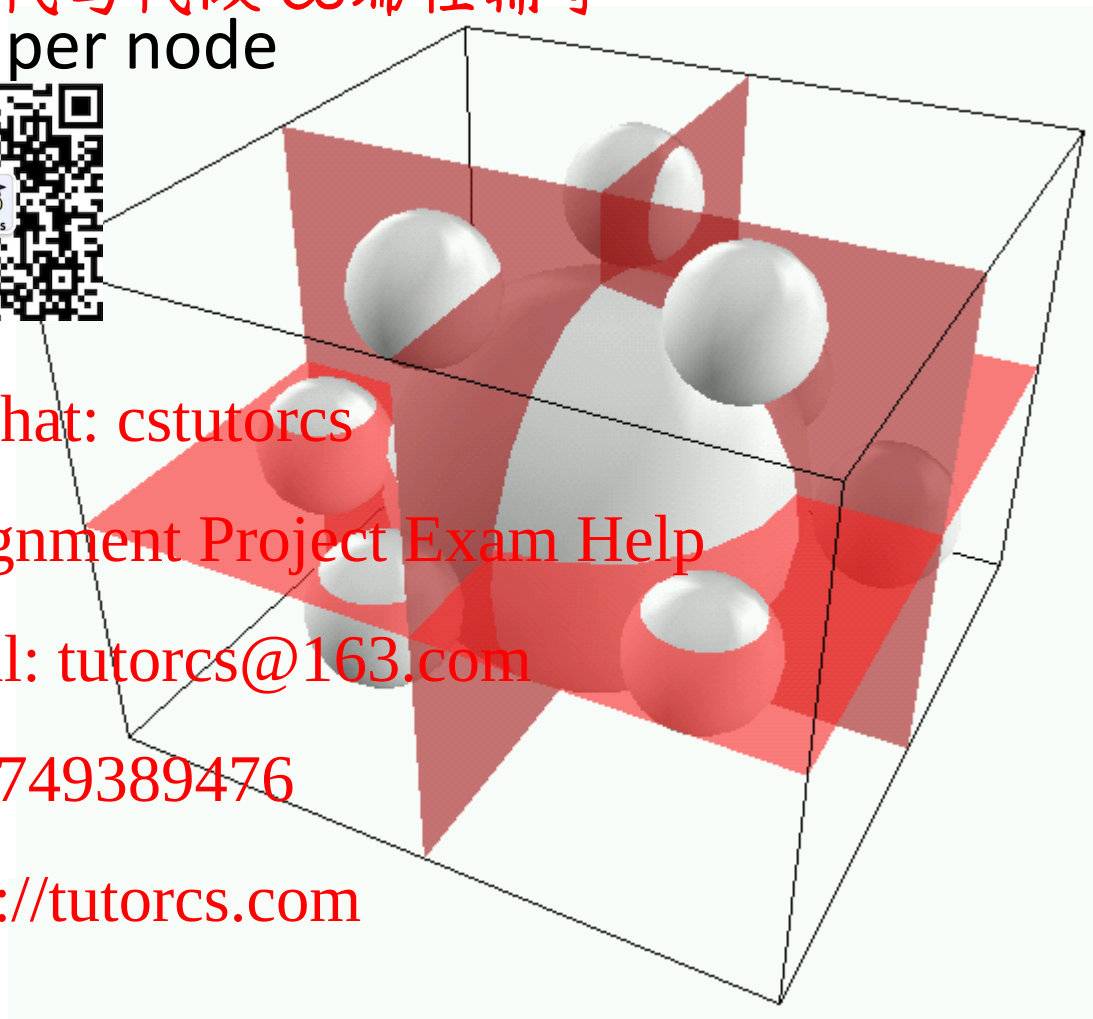

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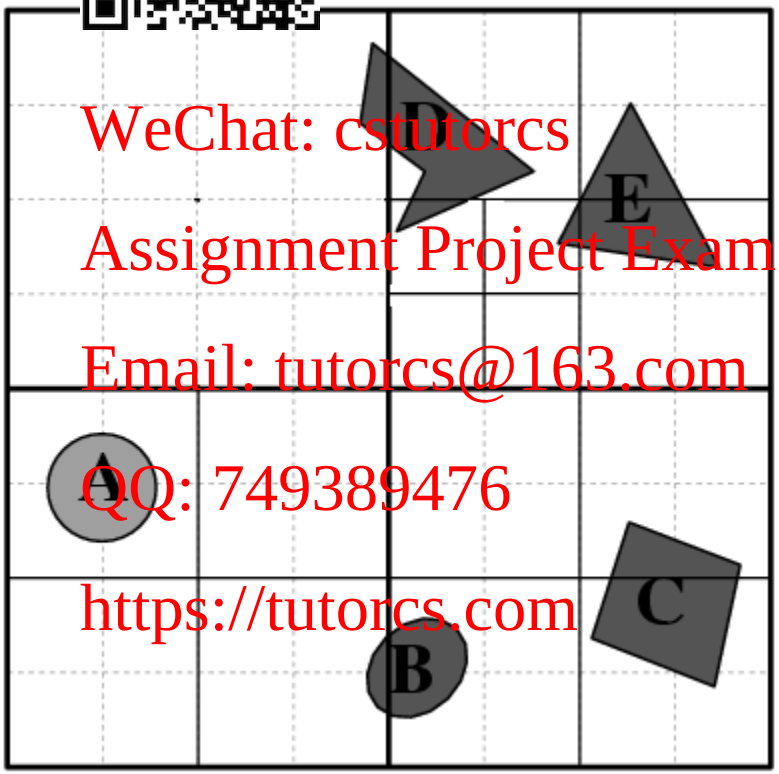
Octrees for Scene Graph Hierarchy

- Octree construction (Quadtree in 2D)
  - Generate octree for models until no cell contains more than one model
  - Group models/parts in the same cell at the same level



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kD-Trees

- Input: n points in k dimensions
- Output: tree that *partitions space at axis-aligned planes*
  - Each point is contained in its own box-shaped region

input output

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kD-Trees

- Generalisation of binary trees
  - At each node find a point which *separates* remaining points into two (approximately) equal sized sets
- In k dimensions, repeat per level:
  - *Choose* one dimension
  - *Sort* points in 1D
  - *Split* points at median
- Choice of dimension:
  - Regular, e.g. x, y, z, x, y, . . .
  - Dimension where distance between points is maximal
  - Some other clever strategy . . .

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kD-Trees

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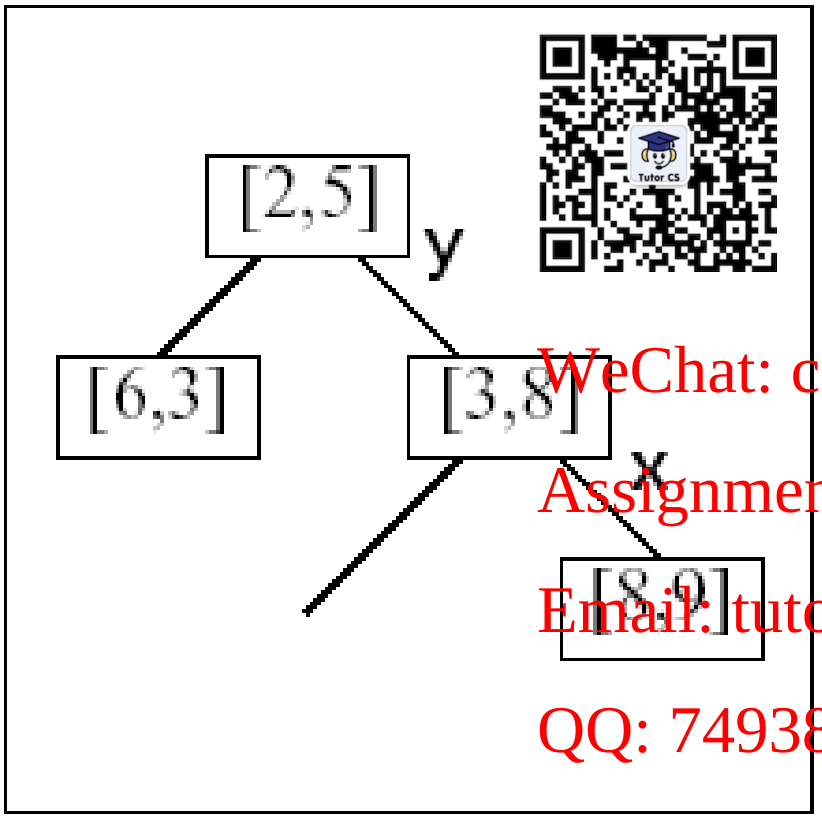

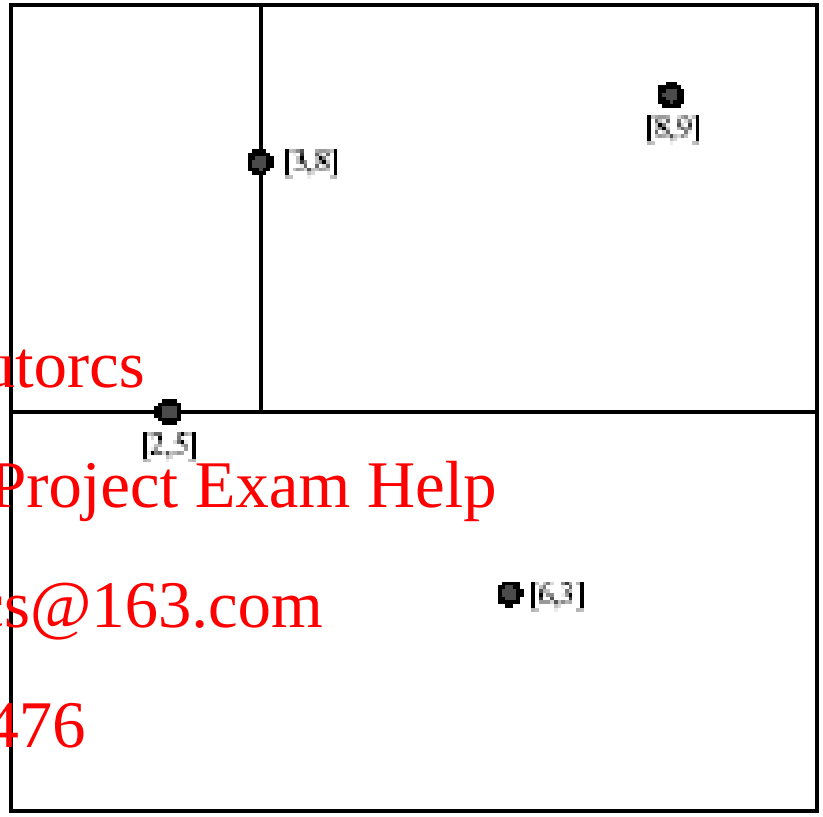

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kD-Tree Generalisation

- kD-Trees can be generalised to handle models
  - Median cut in x, then y . . .
  - Search for best g[illegible] a small set of plane orientations

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- kD-Tree gives hierarchy for scene graph

BSP-Trees

- Use a *binary space partitioning* (BSP) tree to order models
- Identify planes to *partition objects* into those in front of and those behind planes hierarchically
  - For polygons we choose one of them to define a *partitioning plane*
  - Polygons intersecting the plane are cut in two
  - Recursively continue splitting the polygon sets
- Particularly useful when view point changes, but objects remain at same position (partitioning does not change)
- kD-tree is a special case of BSP-tree

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BSP Tree Example

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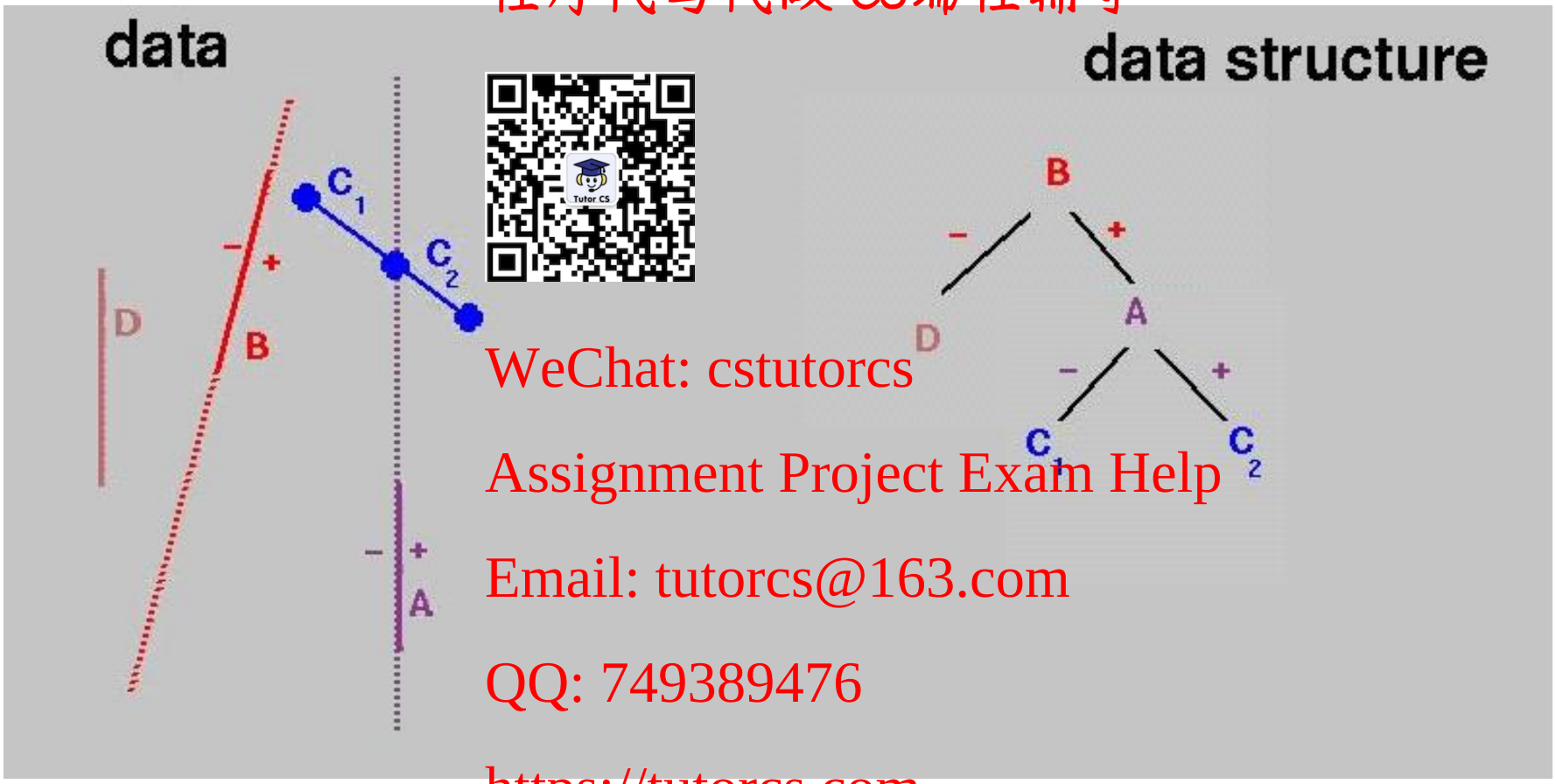

Multi-resolution models

- Hierarchical representation also suitable for simple *multi-resolution models*
  - Represent models at different levels of detail (LOD) for efficient rendering and processing

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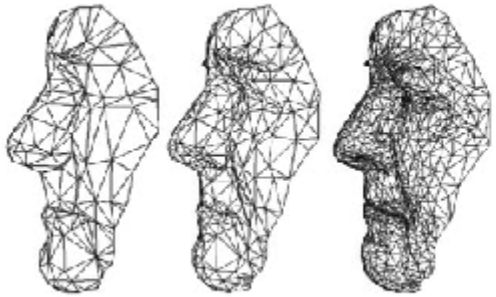

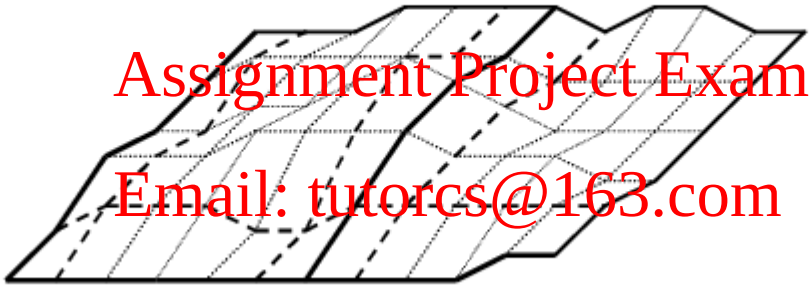

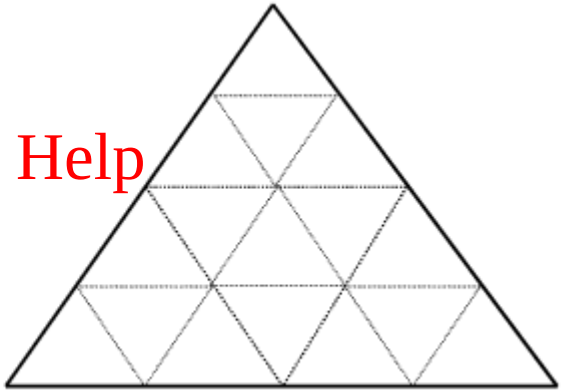

Multi-resolution Scene Graph

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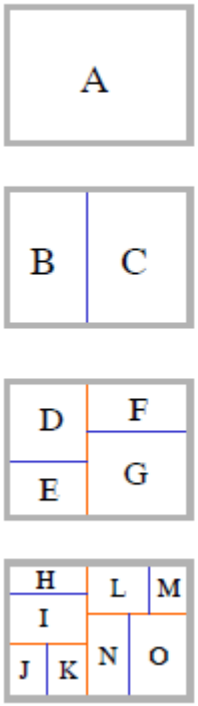

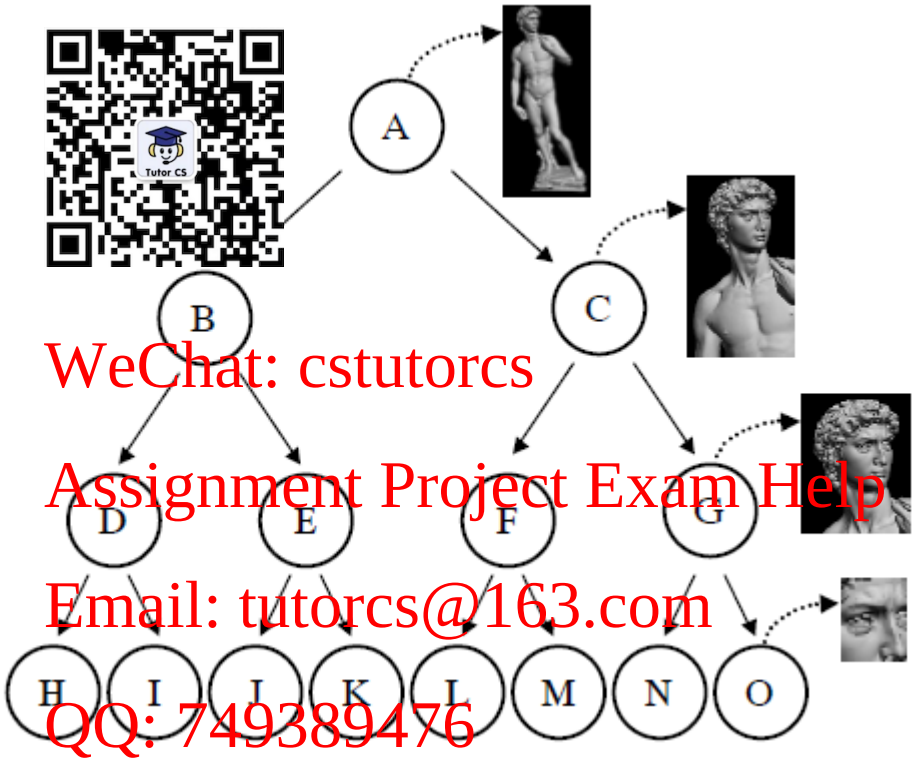

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Multi-resolution Scene Graph

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Scene Graph Issues

- *Minimise transformations*
  - Each transformation is expensive during rendering, etc.
  - Need automatic algorithms to reduce transformation nodes
- *Minimise attribute changes* (materials, etc.)
  - Each state change is expensive during rendering
- Many more scene graph optimisation problems. . .

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Summary

- What is a scene graph / tree?
- Explain the principles of the following spatial data structures:
  - Uniform grid
  - Octree
  - kD-tree
  - BSP-tree
- Given a set of objects, how are these data structures constructed?
- How can these data structures be used to improve scene graph performance?

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