Chapter 2
Polygon mesh in OpenGL ES
Modeling

- A *model* is referred to as a computer representation of an object, and *modeling* is the process of creating the objects in the virtual environment.
- The most popular modeling method in games is using *polygons*, and the model is called a *polygon mesh*.
- The simplest polygon is a triangle. The only polygon OpenGL ES supports is triangle and so polygon mesh in OpenGL ES equals *triangle mesh*.
- Given an object, its polygon mesh may have different resolutions. Shown below is a set of polygon meshes for a sphere.

![Polygon Meshes for a Sphere](image)

- Tradeoff between accuracy and efficiency: As the resolution is increased, the mesh becomes closer to the original curved surface, but the time needed for processing the mesh is increased.
# Polygon Mesh – Non-indexed Representation

- The vertices are enumerated in a memory space, named *vertex array*.
- Three vertices are read in linear order to make up a triangle.

![Triangle with vertices](image)

- It is inefficient because the vertex array contains redundant data.
  - In the so-called *regular mesh*, a vertex is usually shared by six triangles. Given $n$ vertices, the vertex array would have about $6n$ vertices.
- What a waste of storage!
A better method is using a separate index array.

- A vertex appears only once in the vertex array.
- Three indices per triangle are stored in the index array.

The vertex data stored in the vertex array include not only positions but also normals, texture coordinates, and many more. Therefore, the vertex array storage saved by removing the duplicate data outweighs the additional storage needed for the index array.
Vertex Normal

- Vertex normals play a key role in computer graphics.
- A vertex normal is usually computed by averaging the normals of all polygons sharing the vertex.
- Modeling packages such as 3ds Max do compute vertex normals.
Export and Import

- Game objects created using off-line graphics packages are stored in files and passed to the run-time game program.
  - The process of outputting the data in a format suitable for other applications is called *export*.
  - On the other hand, taking such exported data is called *import*.

For exporting and importing, simple scripts or programs are used. For example, 3ds Max provides MAXScript and an exporter can be written using MAXScript.

In 3ds Max, a lot of file formats are supported for export. Among the popular are OBJ and FBX.
Consider a low-resolution mesh of a unit sphere.

- The spherical coordinates are uniformly sampled at every 45 degrees such that the mesh is composed of 26 vertices in total.

- Shown below are some fractions of the OBJ file, where v stands for vertex position, vn stands for vertex normal, and f stands for face or triangle. The first v is indexed by 1 and so is the first vn. A triangle is defined by three instances of v//vn.

```plaintext
# 26 vertices
v 0.000 1.000 0.000
g Sphere001
v 0.000 0.707 0.707
f 1/// 2// 3//3
v 0.500 0.707 0.500
f 2/// 4//4 5//5
v 0.000 0.000 1.000
f 5/// 3//3 2//2
v 0.707 0.000 0.707

# 48 faces
f 18/// 10///10 17///17
:

# 26 vertex normals
vn 0.000 1.000 0.000
vn 0.000 0.663 0.748
vn 0.529 0.663 0.529
vn 0.000 0.000 1.000
vn 0.707 0.000 0.707
vn 0.000 -0.707 -0.707
```

---

Computer Graphics with OpenGL ES (J. Han)
The triangle mesh stored in an OBJ file is exported into OpenGL ES to fill the vertex and index arrays.

As the mesh is composed of 48 triangle, the index array has 144 (48 times 3) elements.