Lighting in Computer Graphics

1   Shading

- Generally, the process for re-creating the phenomenon where colour differ from surface to surface due to lighting

- In CG, shading is the process of altering the colour of an object/surface/polygon, based on

    - The type of light source that is emitting light
    - How the light is reflected from object surfaces and enters the eye

    to create a photo realistic effect

2   Normal Vector

- The orientation of a surface is specified by the direction perpendicular to the surface and is called a normal (normal vector)

- A surface has a front and back face, each side has its own normal

3   Types of shading

Flat shading

- Assign a single colour to each face (triangle) of an object

Gouraud (smooth shading)

- Apply lighting against the normal vector at each vertex to calculate the vertex colour (vertex shader)

- Colours across a face are generated by interpolating colours obtained at the corner vertices of the face (rasterisation)

Phong Shading

- Normal vector at each point over an object surface is obtained by interpolating normal vectors of the corner vertices of the surface (rasterisation)

- Colouring of each surface point will be calculated by applying lighting against the interpolated normal vector at the point (fragment shader)

4   Types of light source

Definition: Directional light

Like the sun that emits light naturally (from very far away, generating parallel light rays)

Definition: Point light

Like a light bulb that emits light artificially in all directions from a point

Definition: Ambient light

Represents indirect light, that is, light emitted from all light sources and reflected by walls or other

Directional light   Point light   Ambient light
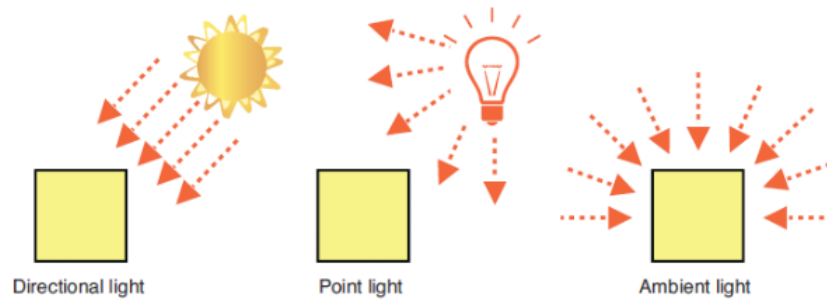
5   Types of reflected light

- Illuminate objects: How light is reflected by the surface of an object and then enters the eye

- Colour of the surface determined by:

    - Type of the light (colour and direction)
    - Type of surface of the object (colour and orientation)

Surface colour by diffuse and ambient reflection = surface colour by diffuse reflection + surface colour by ambient reflection

5.1   Ambient reflection

- Ambient reflection is reflection of light from indirect light sources

- Illuminates an object equally from all directions with the same intensity, its brightness is the same at any position
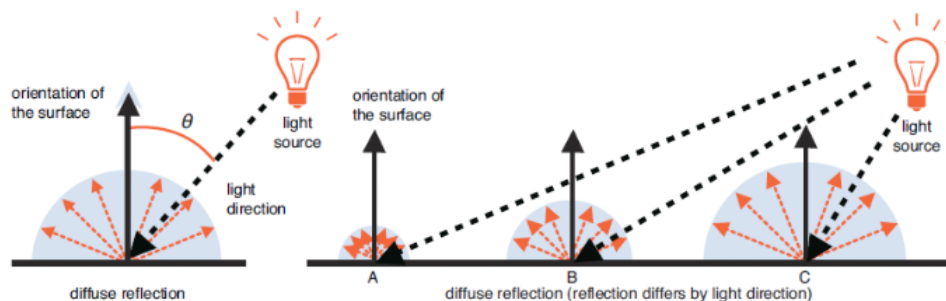
Surface colour by ambient reflection = light colour × base colour of surface

orientation of the surface

ambient reflection   ambient reflection (the same reflection at any position)
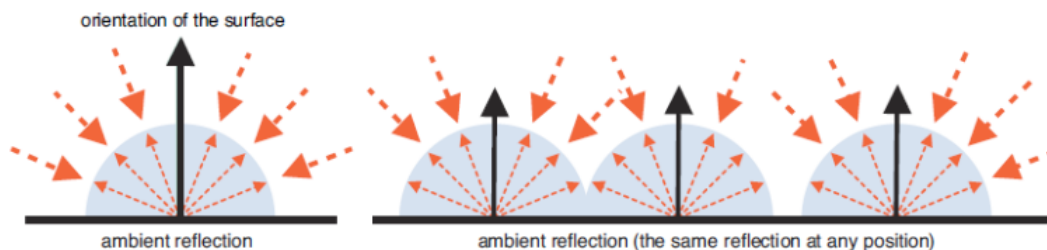
5.2   Diffuse reflection

- Reflection of light from a directional light or a point light

- Light is reflected equally in all directions from where it hits (due to rough surface)

- θ: Angle between light direction and surface orientation (direction "perpendicular" to the surface)

Surface colour by diffuse reflection = light colour × base colour of surface × $\cos \theta$

orientation of the surface θ light source   light direction   orientation of the surface   light source

diffuse reflection   diffuse reflection (reflection differs by light direction)

5.2.1   Calculating $\cos\theta$

$\cos\theta$ is derived by calculating the dot product of the light direction and the orientation of a surface
$\cos\theta$=light direction $\cdot$ orientation of a surface

6   Using a point light object

- In contract to a directional light, the direction of the light from a point light source differs at each position in the 3D scene

- So, when calculating shading, you need to calculate the light direction at the specific position on the surface where the light hits

- Light direction changes: pass the position of the light source and then calculate the light direction at each vertex position