

Assignment #2 - Reflection of an Object in a Mirror; 3D Graphics

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1 Assignment

2 Motivation

3 Our solution

- Examples
- General Solution
- The Limitations of our Solution

4 Conclusion

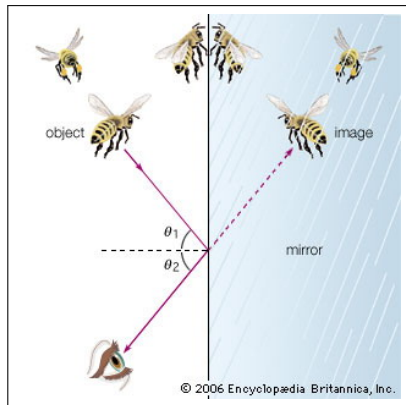
- Further Work

Assignment

- Global illumination phenomena, such as reflections, are not computed by the local lighting model used by the 3D graphics rasterization - based pipeline.
- Our goal is to develop a way to visualize, given a large quadrilateral (a mirror) on the plane $y=0$, and an object near the quadrilateral, the reflection of the object in the mirror.
- We need to verify that our method is correct by building a X3D scene as above, where we apply our method to visualize the object reflection on the mirror.
- In the end we are supposed to write down all the limitations of our solution, and think about possible ways to improve it (e.g. what to do when the mirror is not on the $y=0$ plane?)

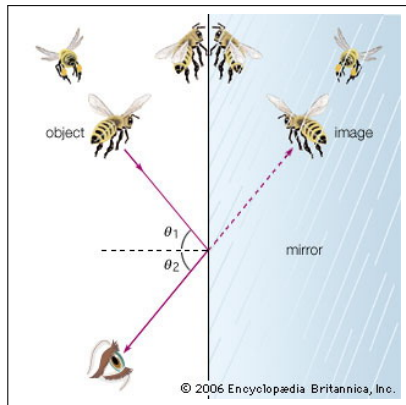
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- Physics - the Law of Reflection.



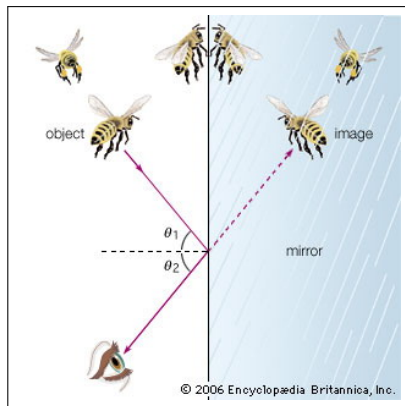
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Motivation

- Physics - the Law of Reflection.
- Basic computer graphics concepts.
- In order to create reflected object in a scene, it is necessary to understand the transformations which will be applied.



Our Solution

- All we can do is to draw all the objects in front of the mirror and their mirror reflections, but not the objects behind the mirror.

Our Solution

- A simple example of using reflections is to reflect the scene in a mirror on $y = 0$ plane. In this type of application it is reasonable to assume that the remainder of the scene lies above the $y = 0$ plane.

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- A simple example of using reflections is to reflect the scene in a mirror on $y = 0$ plane. In this type of application it is reasonable to assume that the remainder of the scene lies above the $y = 0$ plane.
- To get the reflection it is necessary to render the scene as if it was below ($-y$ direction) the $y = 0$ plane.

Our Solution

- To do this the y-coordinates of model need to be negated. We achieved this by scale transformation with value '1, -1, 1'.

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} x & 0 & 0 \\ 0 & -y & 0 \\ 0 & 0 & z \end{bmatrix}$$

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- Note that this is independent of where the viewer is located.

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- First example - Reflection of the arbitrary (freeform) object.
- Second example - Reflection of several objects.

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- General case is when a mirror is not in $y = 0$ plain - the case when the mirror is allowed to have any position and orientation within the space.
- In this case, solution is to transform scene so that mirror is transformed to $y = 0$ plane, reflect and transform back (i.e., reducing to our case).

General Problem

- Let us have one vertex of the planar reflector (P) and the vector of the plane where the mirror is (it is the vector normal to the reflecting plane, vector V).

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- Now we can determine the matrix of transformation which will create the reflected objects:

$$T_M = \begin{bmatrix} 1 - 2V_X^2 & -2V_XV_Y & -2V_XV_Z & 2(P \cdot V)V_X \\ -2V_XV_Y & 1 - 2V_Y^2 & -2V_YV_Z & 2(P \cdot V)V_Y \\ -2V_XV_Z & -2V_YV_Z & 1 - 2V_Z^2 & 2(P \cdot V)V_Z \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\text{where } P \cdot V = P_XV_X + P_YV_Y + P_ZV_Z$$

The Limitations of Our Solution

- Problem with the objects behind the mirror.

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- Problem with the objects behind the mirror.
- Our application runs slower due to the drawing objects even when they can not be seen from current viewpoint.

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- We enjoyed working on it!

Further Work

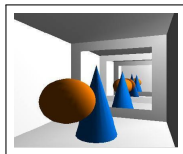
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- Multiple mirrors rendering - render the normal view, then do other transformations for each mirror.

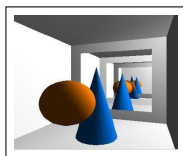
Further Work

- Rendering a 2d reflection, a more appropriate model of the real world.
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- Recursive reflections between mirrors - After rendering the reflected area inside the mirror surface, render the mirrors inside the mirror surface, and so on.



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- Reflection in curved surface mirrors.

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