To predict the position of the discontinuities shadow detection algorithms ar used and the problem is usually couched in terms of visual events and critica surfaces. Two types of visual events can be considered VE and EEE. VE o vertex–edge events occur when a vertex of a source 'crosses' an edge of a occluding polygon known in this context as a receiver. Figure 11.19 shows th interaction between a vertex of a triangular source and an edge of a rectangula occlude. The edge and vertex together form a critical surface whose intersectio with a receiving surface forms part of the outer penumbra boundary. For eac edge of the occluder a critical surface can be defined with respect to each verte in the source. We can also define EV events which occur due to the interactio of a source edge with a receiver polygon.

VE events can cause both D^1 and D^2 discontinuities as Figures 11.20 and 11.2 demonstrate. Figure 11.20 shows the case of a D^1 discontinuity. Here there is th coincidence that the edge of the occluder and the source are parallel. Both vertice V_1 and V_2 contribute to the penumbra. As we travel outwards from the umbra alon path *xy*, the visible area of the source increases linearly and the radiance exhibit piecewise linearity or D^1 discontinuities. A D^2 discontinuity caused by a VE event i shown in Figure 11.21. In this case, a single vertex of the light source is involve along the path *xy*. As we travel outwards from the umbra the visible area of th source increases quadratically and the radiance exhibits D^2 discontinuities.

EEE or edge–edge–edge events occur when we have multiple occluders. Th important difference here is that the boundary of the penumbra – the critical curv – is no longer a straight line as it was in the previous VE examples but a conic. Th corresponding discontinuities in the radiance function along the curve are D^2. Als the critical surface is no longer a segment of a plane but is a (ruled) quadric surface

Visual events can occur for any edges and vertices of any object in the scene For a scene with n objects there can be $O(n^2)$ VE critical surfaces and $O(n^3)$ EE critical surfaces. Because of the cost and the higher complexity of EEE event approaches have concentrated on detecting VE events.

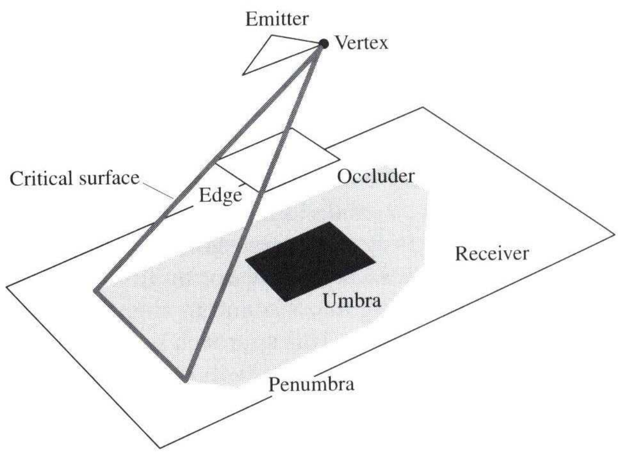
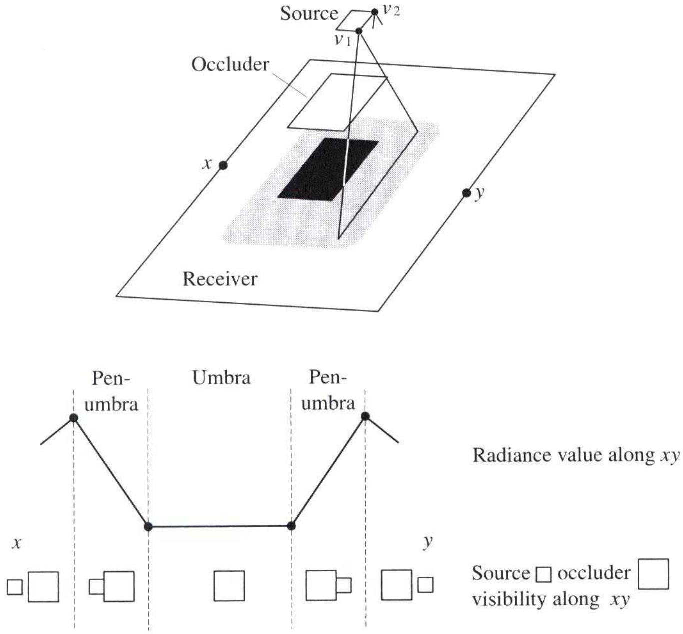
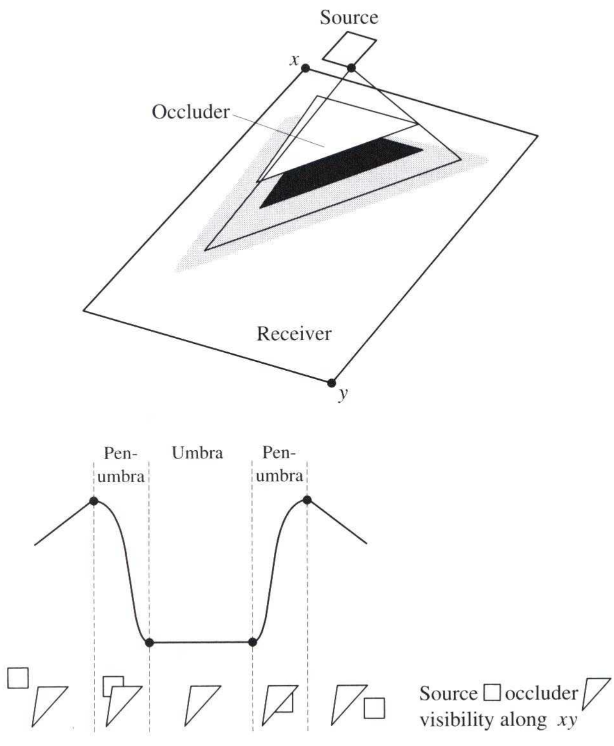


Figure 11.19
VE event: the edge of the occluder and a vertex of the emitter form a critical surface whose intersection with the receiver forms the outer boundary of the penumbra (after Nishita and Nakamae (1985)).



ure 11.20
event causing a D^1
continuity (after Lischinski
al. (1992)).



gure 11.21
E event causing a D^2
scontinuity (after Lischinski
al. (1992)).

A straightforward approach by Nishita and Nakamae (1985) explicitly dete mines penumbra and umbra boundaries by using a shadow volume approacl For each object a shadow volume is constructed from each vertex in the ligl source. Thus, there is a volume associated with each light source vertex just as it were a point source. The intersection of all volumes on the receiving surfac forms the umbra and the penumbra boundary is given by the convex hull cor taining the shadow volumes. An example is shown in Figure 11.22.

We will now describe in some detail a later and more elaborate approach b Lischinski *et al.* (1992) to discontinuity meshing. This integrates discontinuit meshing into a modified progressive refinement structure and deals only with V (and EV) events. This particular algorithm is representative in that it deals wit most of the factors that must be addressed in a practical discontinuity meshin approach including handling multiple light sources and reconstruction problem:

Lischinski *et al.* build a separate discontinuity mesh for each source, accumu lating the results into a final solution. The scene polygons are stored as a BSP tre which means that they can be fetched in front-to-back order from a source ve tex. For a source the discontinuities that are due to single VE events are locate as follows. Figure 11.23 shows a single VE event generating a wedge defined b the vertex and projectors through the end points of the edge, *E*. The event i processed by fetching the polygons in the order *A*, *B* and *C*. *A* is nearer to th source than *E* and is thus not affected by the event. If a surface (*B* and *C*) face the source then the intersection of the wedge with the surface adds

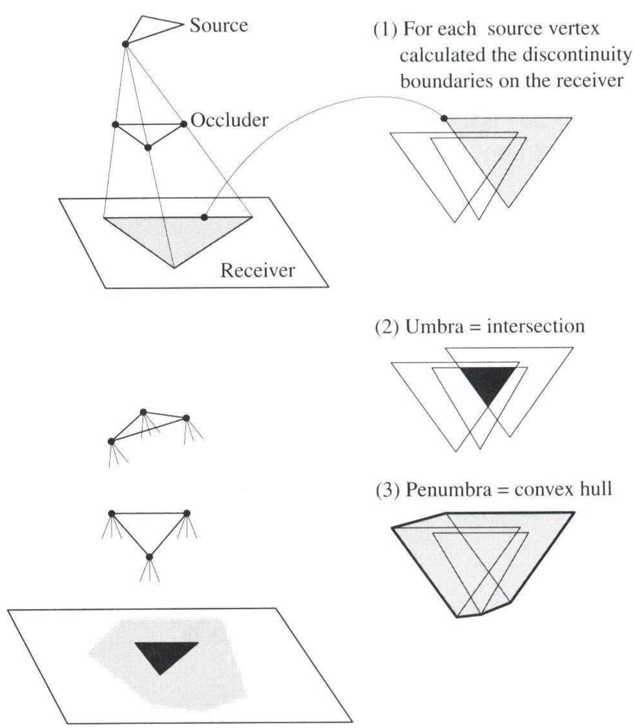


Figure 11.22
Umbra and penumbra from shadow volumes formed by VE events.