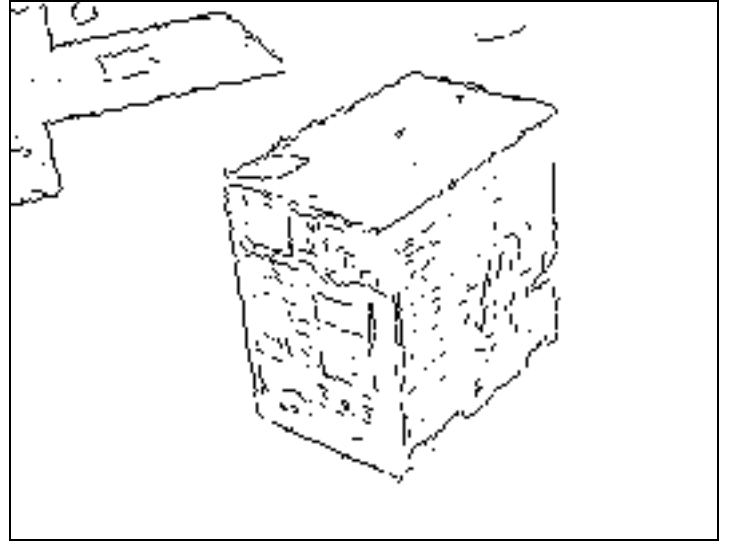
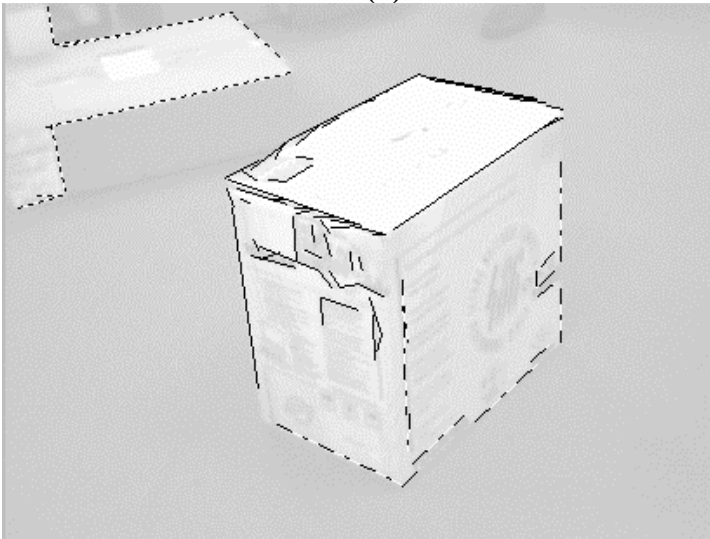




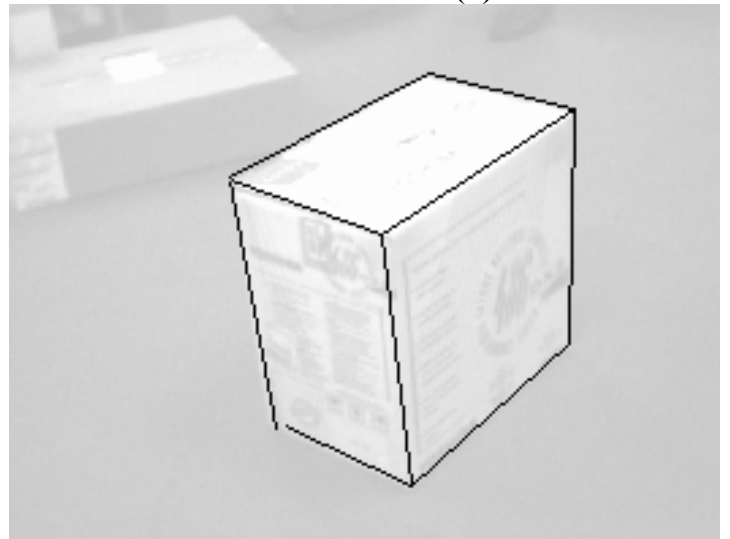
(a)



(b)



(c)



(d)

Figure 1. Three main stages of the Convex Hull Approach. (a) Original Image; (b) Lines extracted Direct Line Detection algorithm; (c) Clusters (indicated in different line styles); (d) The final outline of the box.

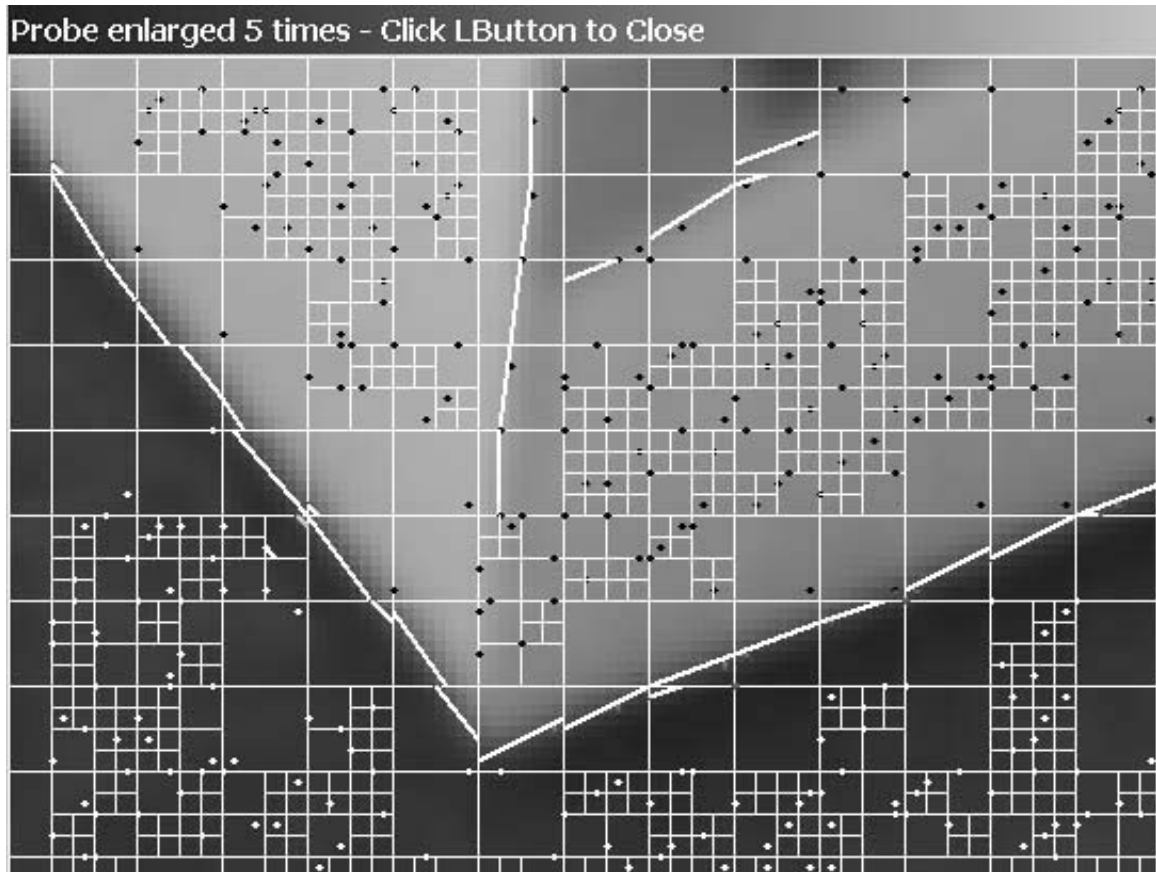
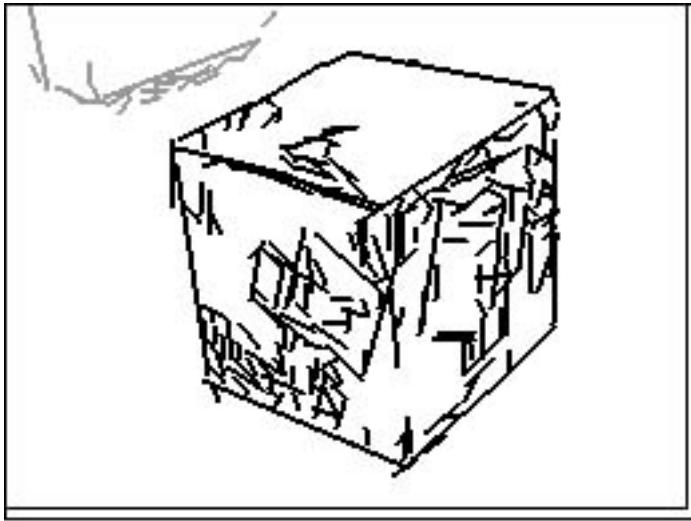
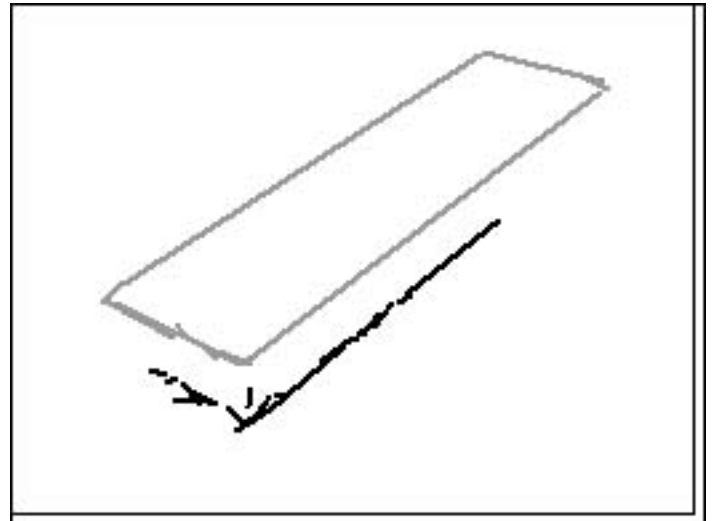


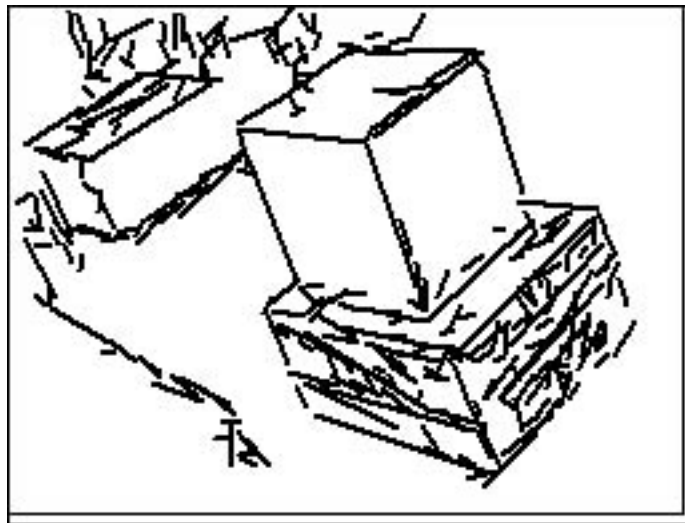
Figure 2: Direct Line Detection. The thin white lines show how the image is subdivided. The thick white lines depict the line segments found within each subdivided block. The dark dots in the light areas and the white dots in the dark areas indicate the maximum gradient pixel.



(a)



(b)

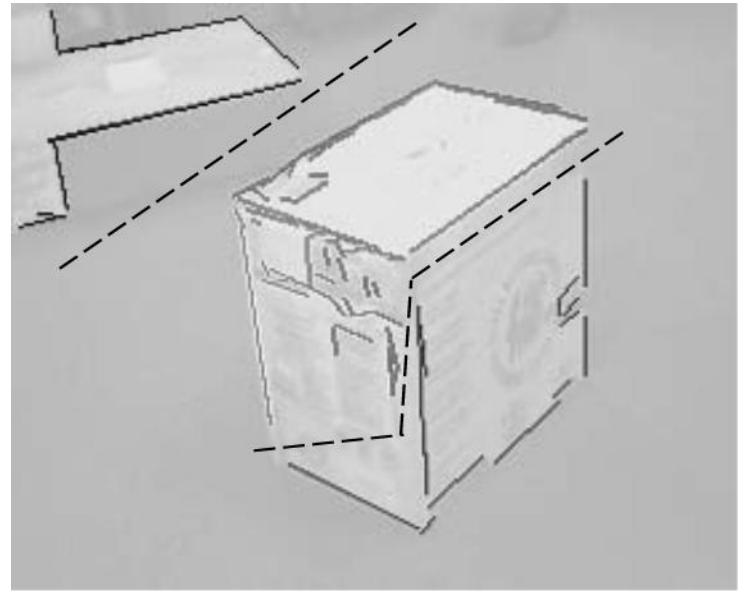


(c)

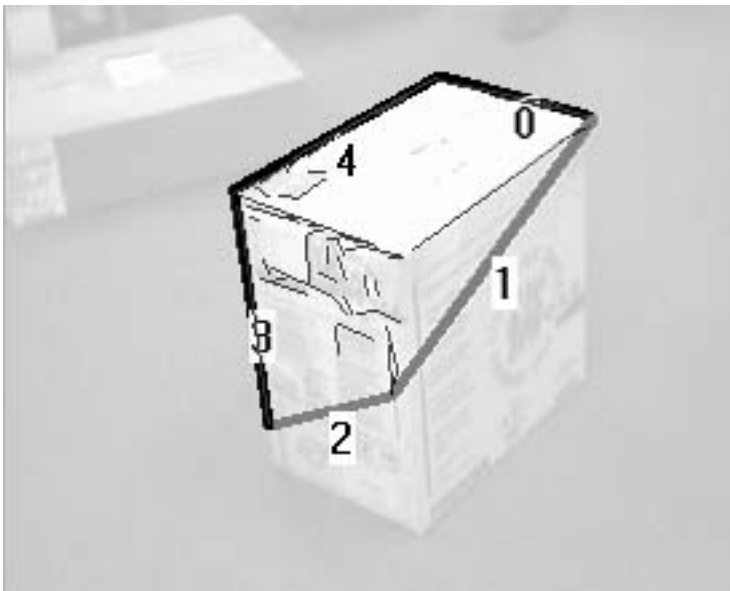
Figure 3: Examples of the relationship between proximity clusters and solid objects. (a) Each cluster corresponds to an object; (b) One object contains two clusters; (c) One cluster contains several objects.



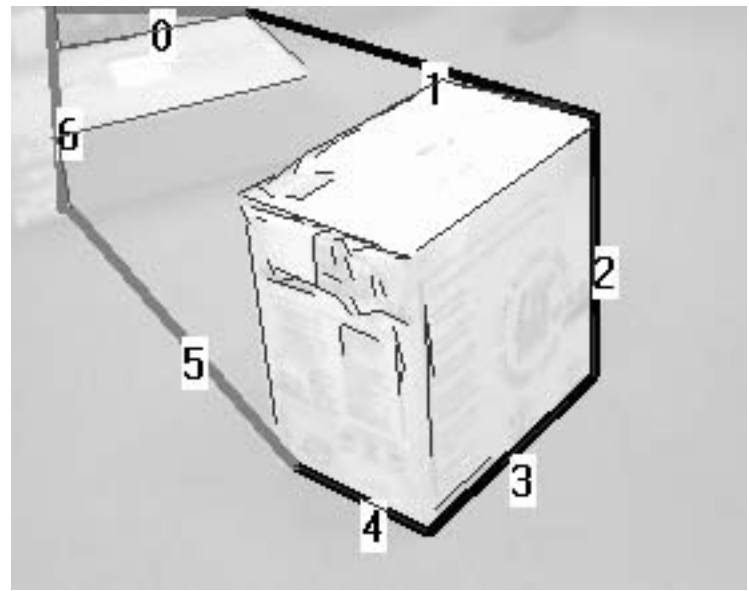
(a)



(b)

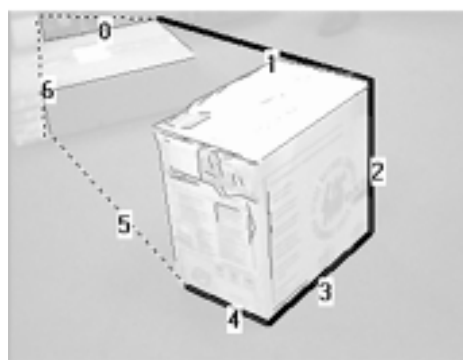


(c)

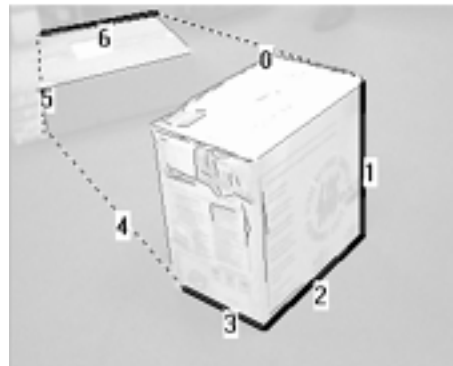


(d)

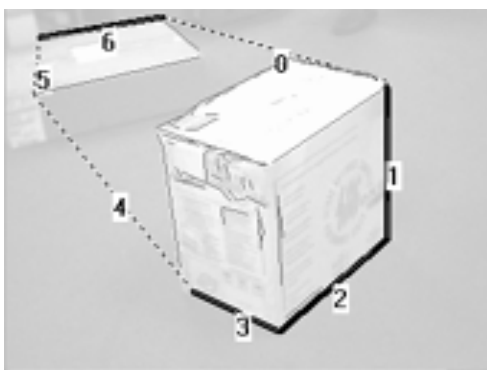
Figure 4: Illustrations of clustering and computing the convex hull. (a) Original Image; (b) Line segments found with three proximity clusters marked in light gray, dark gray and black. The dashed lines are drawn to delineate the three clusters; (c) Convex hull (numbered lines) of the middle cluster of Figure 4(b); (d) Convex hull (numbered lines) of all clusters. Thick black lines mark edges of high confidence and thick dark gray lines marks edges of low confidence (they do not overlap with lines previously found). Note that line 1 in (d) is not low confidence because of partial overlap with a previously found line.



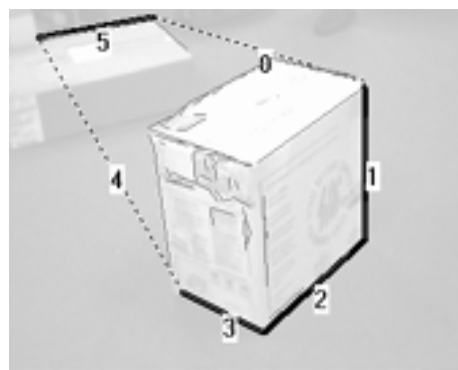
(a)



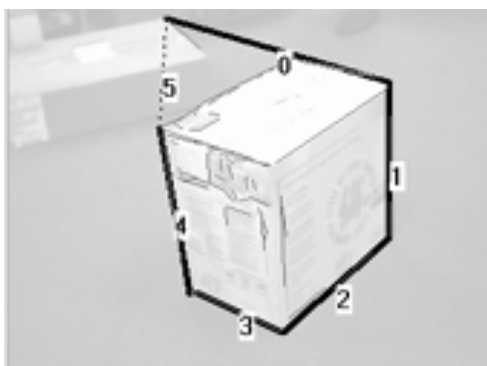
(b)



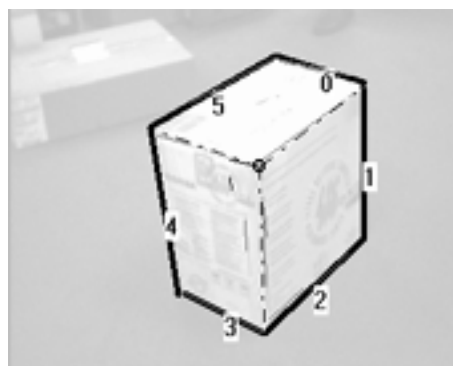
(c)



(d)



(e)

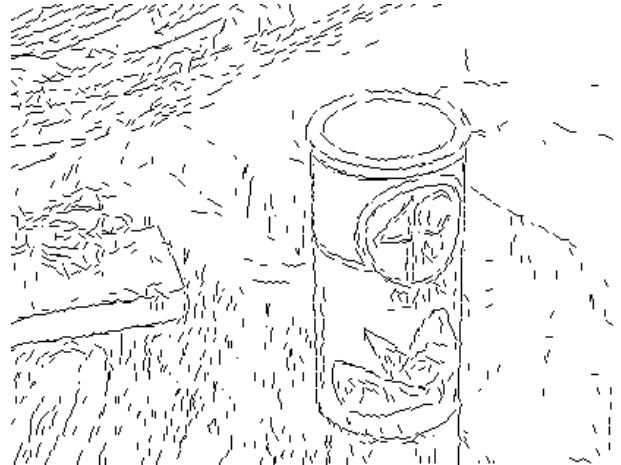


(f)

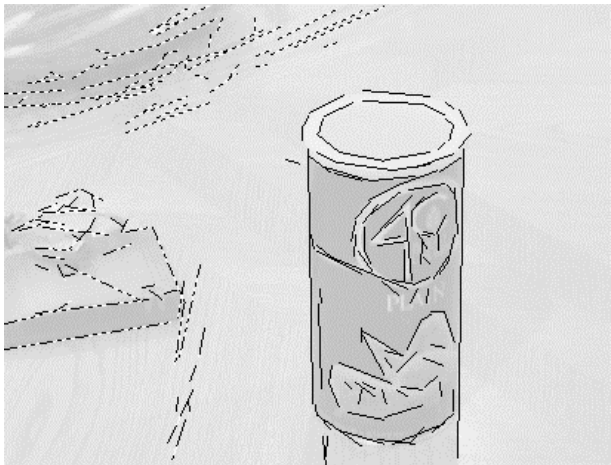
Figure 5: Illustration of the automatic editing of the convex hull for a rectangular object. (a) Starting configuration with the convex hull of all the clusters (same as Figure 3d); (b) Result after removing lines 5-6-0; (c) and (d) Results after removing (relabelled) lines 4-5; (e) Results after removing the sharp angle formed by 4 and 5; (f) Results after removing the sharp angle formed by 5 and 0.



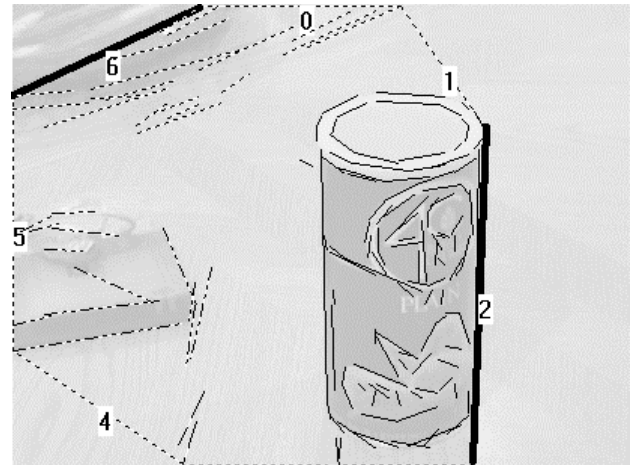
(a)



(b)



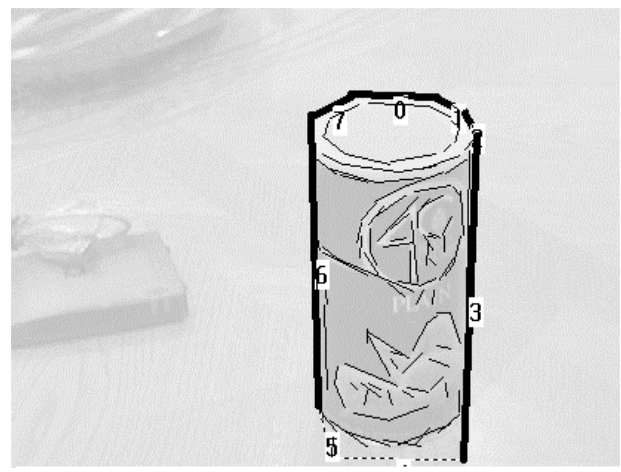
(c)



(d)

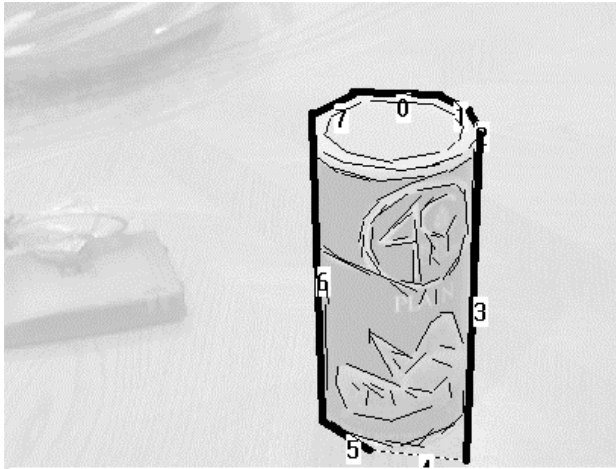


(e)

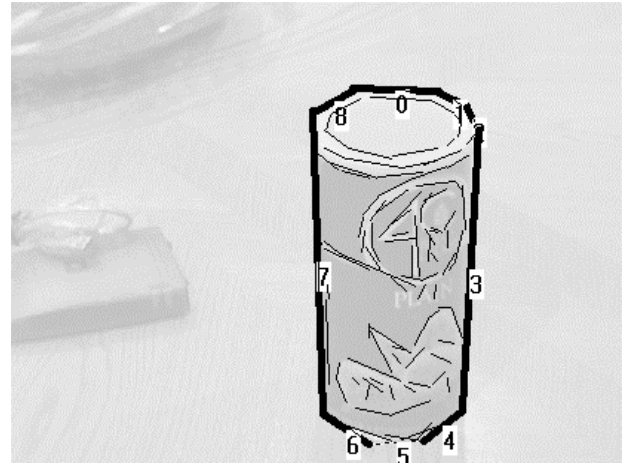


(f)

Figure 6 (cont)



(g)



(h)

Figure 6: Illustration of the automatic editing of the convex hull for a cylindrical object. (a) Original image; (b) Direct Line Detection; (c) Proximity Clusters; (d) Convex hull of all clusters; (e) Convex hull of main cluster; (f) Remove line(s) at 5-6; (g) Remove line(s) at 4-5; (h) Remove sharp angle at 3-4.

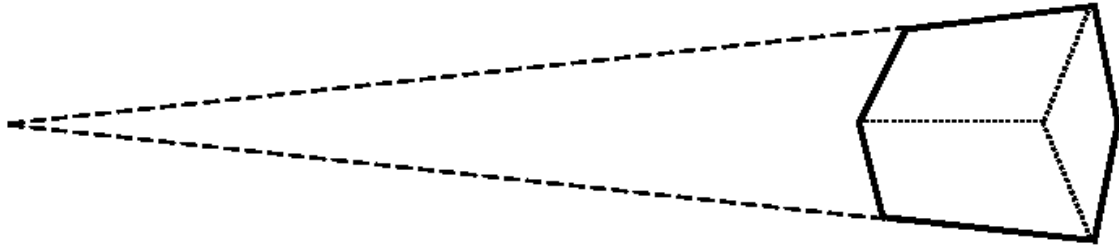
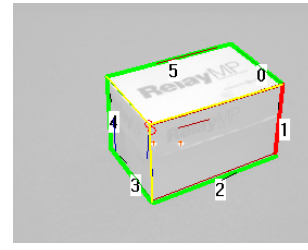
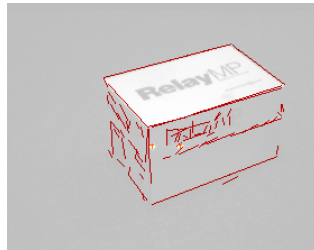
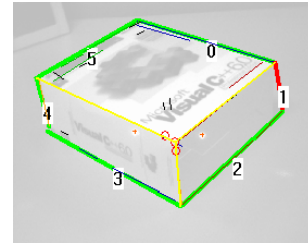
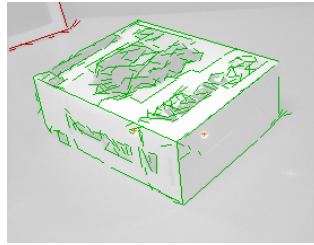


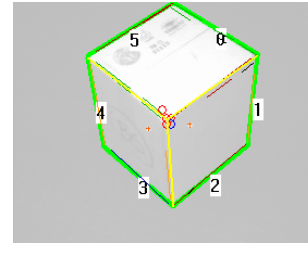
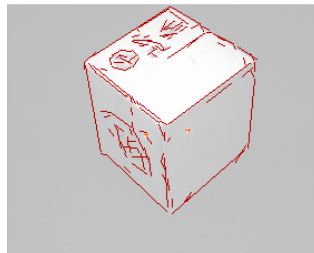
Figure 7: Illustration of the significance of the function $z()$ used to evaluate whether two opposite sides of a hexagon (shown in heavy lines) are nearly parallel. The dashed lines are the extensions of these sides and in the above figure the value of d_{min} is about 5.5 that results in a value of $z()$ equal to about $5/3$. (The dotted lines inside the hexagon do not enter in any of the calculations, they are used only to illustrate how the hexagon is related to the projection of a rectangular box.)



(a) Example 1



(b) Example 2



(c) Example 3

Figure 8: Typical results of the dimensioning system based on the Convex Hull algorithm. (a) Example 1: real dim. [17.75, 11.6, 9.75], average est. dim. [16.97, 11.33, 9.69], RMS err 0.51 or 1.3%; (b) Example 2: real dim. [9.5, 7.75, 3.5], average est. dim. [8.29, 6.99, 3.31], RMS err 0.83 or 4%; (c) Example 3: real dim. [9.5, 9.125, 9], average est. dim. [9.12, 9.01, 8.52], RMS err 0.32 or 1.2%. All measurements are in inches.