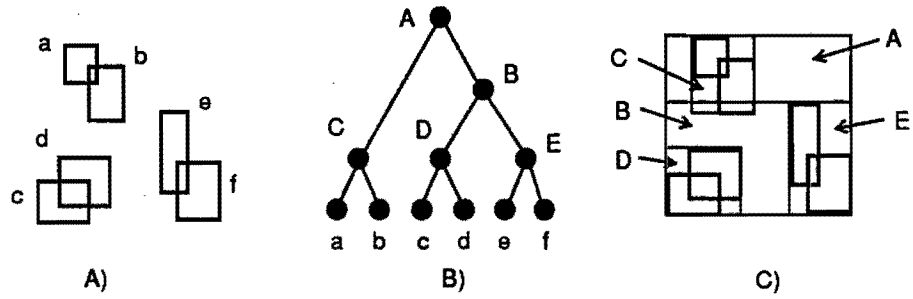
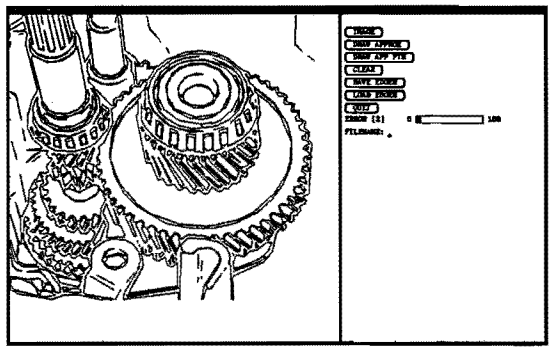
Boxtrees for Fast Image Feature Access

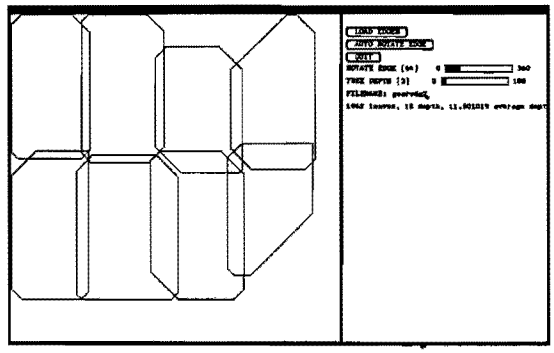
Stephen M. Omohundro



A) B) C)

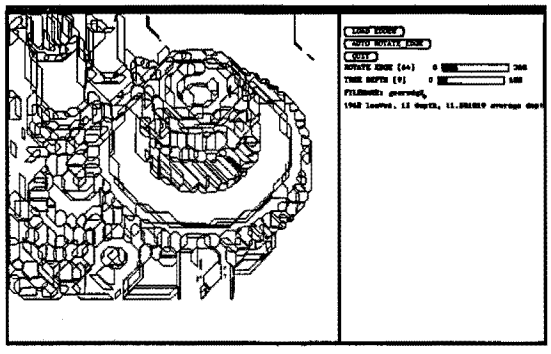
D)

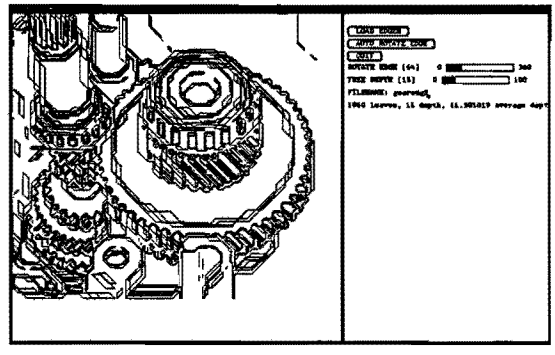




E)

F)





G)

This demonstration shows one use of *boxtrees*, a geometric data structure with a wide variety of practical applications. In general, boxtrees provide efficient access to geometric entities in multi-dimensional spaces. They are binary trees in which a hyper-rectangular region (a box) is associated with each node such that each parent's box is the smallest which contains the two boxes of its children. Figure A) shows a set of boxes in the plane, B) a binary tree over these boxes, and C) all the boxes in the boxtree. Such structures support efficient geometric search by hierarchically pruning away irrelevant parts of the data. In D) we show a set of edges extracted from a scanned image of a gear. The two-dimensional image is embedded in a four-dimensional space by sending the image point (x,y) to (x,y,x+y,x-y). Boxes in this four-dimensional space correspond to octagons in the image. The four-dimensional space is used because octagons bound line segments more tightly than rectangles would. Figures E), F) and G) show the decompostions represented in the tree at levels 3,9, and 15. This structure allows the system to quickly find all edges in the vicinity of a query edge. If this same kind of structure is used to decompose spaces which include image feature dimensions, more specific queries may be efficiently supported. In the demonstration, a tree is built by decomposing a five-dimensional space which includes the angle of the edges as a fifth dimension and it efficiently supports queries which seek nearby parallel edges to a given edge.

More information on heuristics for constructing this kind of structure may be found in "Five Balltree Construction Algorithms", ICSI Technical Report TR-89-063.