each maf operation as far as possible. It can be shown that the modified algorithm generates no more than 

$$3h + f + r + v - 1$$

operators.\(^\text{11}\) The enhanced algorithm is optimal in that it always generates the shortest sequence of Euler operators in our collection that is capable of creating the solid.

**Discussion and conclusions**

Euler operators are currently used in a number of geometric modeling systems\(^\text{12,13}\) as the basic definition operations. Our work—in particular, the inversion algorithm—shows that Euler operators may be used as a basis for a comprehensive solid modeler also in a more general sense. By the inversion algorithm, we are able to generate sequences of Euler operators corresponding to the results of set operations or other solid definition and manipulation operations. These lists form the main external representations of the system.

Certain algorithms can operate directly on these lists; for instance, any linear transformation (such as rotation or translation) may be applied to a solid by scanning its inversion and transforming all vertex coordinates. As another example, a line figure of a solid can be generated just by scanning through the sequence of operators and storing the coordinates of the vertices created. Also, in those contexts where a BR data structure must be evalu-

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**Figure 17. A worst case example.**

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