Practitioner's Commentary: The Outstanding Snowplow Papers

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All the winning teams approached the problem in similar ways, although with varying degrees of detail. All came to the conclusion that the primary measure of efficiency is the time spent by the two trucks plowing the roads and (with a few exceptions) characterized the problem as the construction of two Euler circuits of lengths as close as possible. Some teams did consider, as a plausible alternative criterion, the removal of snow from selected roads to facilitate access to more populated areas; but they concluded that this would involve traversing large distances over already-plowed roads (and that the computational effort would be much greater). The team from Southern Oregon State presented a detailed solution to plow main thoroughfares first and minor roads last, in addition to the solution using Euler circuits.

Since there are two trucks, it is necessary to partition the graph of roads into two connected subgraphs of total lengths as close as possible. This is not an easy problem at all, but in the present case it is possible to find acceptable approximate solutions. [EDITOR'S NOTE: In fact, it is easy to show that the problem can be reduced to the knapsack problem and hence is NP-hard.] Most teams decided to solve this problem by hand, using two sets of roads and adding a road to whichever set has the smaller current total length. The main advantage of doing this by hand is that it is not easy to use the same idea in a computer program, because the program may choose roads that isolate one of the sets from the remainder of the graph. In this, as in many other problems, hand calculation is a perfectly valid method for constructing a solution. Moreover, the method is sufficiently general to be applicable to similar problems. Of the best papers, the only one that carried out this computation by computer was the one by the team from the University of Alaska—Fairbanks.

Some teams also took into account the number of turns and U-turns in a route as an additional measure of efficiency (or, rather, inefficiency). The USAF Academy team constructed several solutions and compared them according to the number of turns. This team also presented an alternative solution: construct a total Euler circuit first, then divide it as equally as possible between the two trucks. An additional merit of their presentation is that they considered the generalization of the problem to the case of n plows.

The team from Rose-Hulman Institute of Technology presented a delightful algorithm to construct the Euler circuits. The method takes advantage of the fact that the edges in the directed graph come in pairs in opposite directions (one lane in each direction). If the undirected graph of roads were a tree, it would be very simple to traverse each road in both directions with any tree traversal algorithm: use one lane when going from a node to a descendant, and use the other lane when returning. The Rose-Hulman team constructed a spanning tree and traversed it; whenever a node is connected to a road not in the tree, the rule is simply to traverse that road to the next intersection and come back. Their paper also presented a careful discussion of the errors in their computations.

All participants should be commended for their fine work; it is remarkable to see a small group of undergraduate students spend a weekend working on a nontrivial problem, developing a solution, and preparing a comprehensive report.

About the Author

Alejandro Barrero is Assistant Professor in the Computer Science Department of the University of New Mexico. Prof. Barrero received a bachelor's degree in electrical engineering from Universidad Javeriana in Bogota, Colombia. He received master's and doctoral degrees in electrical engineering from the University of Tennessee. Prof. Barrero has been Head Judge for the discrete problem of the Mathematical Contest in Modeling, and served as Computer Science Consultant this year.