A Dynamic Programming Algorithm for Enumeration of Efficient Container Inspection Strategies

Noam Goldberg, Jonathan Word, Endre Boros, Paul Kantor
Rutgers University, DyDAn - Center for Dynamic Data Analysis

Project Scope:
In the container inspection problem we seek to maximize detection of a rare and hazardous cargo subject to a budget constraint. The best detection rate would be obtained by inspecting each and every container, but it is not feasible to do so. In order to satisfy a realistic budget constraint we can inspect only those containers flagged as suspicious in some sequence of tests (e.g. inspection of the manifest or sensor readings). The testing strategies are realized by a decision tree whose leaf nodes represent decisions to either completely examine, or to 'release' the container. We describe optimal testing strategies to be mixtures of decision trees as in Boros et al. [1].

Recent Progress:
Maintaining the assumption that the container tests are stochastically independent, we are able to formulate a dynamic programming algorithm for enumerating all *efficient* testing strategies, that is, a set whose members and mixtures dominate all other strategies in the cost-detection space. We find that the set of *efficient* testing strategies is substantially smaller than the set of all possible testing strategies. While the number of all possible detection trees is at least double-exponential in the number of tests, the dynamic programming algorithm's (worst case) complexity is bounded by an exponential times the size of the output (i.e. the number of *efficient* strategies). Experiments show that, in fact, the algorithm works fast in practice, for the number of tests that are currently being considered.

Future Plans:
We plan to continue extend this research with computational improvements, extension to detection of cargo which is not as rare (that is, which has a non-negligible prior probability), and extension to detection of multiple types of contraband cargo.

Relevance to listed research areas:
This research area is relevant to the areas of *Explosives Detection, Mitigation and Response, Risk and Decision Sciences, Biological Threats & Countermeasures, Advanced Data Analysis and Visualization, Border Security* and *Maritime and Port Security*

Publications:
[1] Boros, E., Fedzhora, L., Kantor, P., Saeger, K., & Stroud, P. (2006). *Large scale LP model for finding optimal container inspection strategies*. RRR 26-2006. http://rutcor.rutgers.edu/pub/rrr/reports2006/26_2006.pdf. To appear in Naval Research Logistics Quarterly.