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Quantitative Decision Tools for the Management and Analysis of the Risk from Terrorist Attacks

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Abstract

A natural epidemic is a disease that suddenly affects many individuals in a short time period, spreading from person to person in a
usually modeled as a random variable because it cannot be anticipated. Epidemics introduced by bioterrorists are planned events by intelligent adversaries, who might also introduce other terrorists' activities that dependon the responses of the defenders. Since these events are not random, models maybe helpful for anticipating terrorist attacks. Since defendingagainst such attacks does not fit into the classical modeling paradigmbecause there is a scarcity of data, the defender must respond quickly, the attacker can also adapt new strategies in response to the actions of thedefender, new modeling strategies are required to improve the strategies of the defender. In this article, a Stackelberg model combined with fault trees is proposed for determining sequential optimal defense strategies for thedefender by identifying minimal cut sets of events that would most likely lead to a successful terrorist attack. Further, if the model can be formulated as a sequence of Markovian state changes based on default trees, a dynamic programming problem with the Bellman equation reduces the solution from evaluating a complex model to evaluating a sequence of simple problems.

Keywords: Risk; Reliability; Fault trees; Sequential games

Introduction

Risk is the potential negative impact (disease) on an individual or asset of value that may arise from a present process or future event. An operational definition of risk is the expected loss (debilitating sickness or death) resulting from the consequence that a hazard (epidemic) has occurred.

Risk assessment consists of tools for determining potential risks as well as the strategies and costs for managing them [1]. It requires an analysis of the underlying process to identify limitations and conditions that contribute to risk. In the study of reliability (engineering) fault trees are graphical representations of cause and effect relationships within a system, and are commonly used for analyzing cost benefit strategies. These trees have an inverted structure with the catastrophic event at the top and possible causes underneath as the mode events. The branches of the tree spread downward, beginning with sub-system failures and ending with component or elementary events. The root cause of the failure is the top event. Once constructed, minimal cut sets are identified that consist of necessary and sufficient combinations of component failures which, if failed, cause the system to fail. Based on simulations and sensitivity studies, cost effective strategies are tested for reducing the risk of system failures. The bottom-up analysis of fault trees, called event trees, is used in system design to evaluate potential risks associated with sets of component failures. Thus, the top-down analysis is used in fault diagnoses once the catastrophic event has occurred, and the branches are studied bottom-up for designing a defense system. Trees are now being developed for dynamically changing systems such as those found in economics and issues related to homeland security.

Game theory is a model for studying decision making strategies of intelligent rational competitors, especially in the presence of minimal data. The Stackelberg model is a specially defined game where the competitors act in sequence rather than at the same time. In the game of defender versus terrorist where the defender lives in a democracy with a free press, the terrorist observes the actions of the defender. At

the default tree. In the more common setting the 2 players have different amounts of information and must use subjective probabilities to determine the expected choices made by an opponent. The solution for each opponent is based on the expected optimal choice of his opponent where the terrorist has at least one option (pure strategy) and the defender might not know all of the potential targets available to the terrorist (mixed strategy occurs when the ĥ ʿ thcurs
opponent [illegible]

carriers and run laboratory tests for the presence of the virus. Instead, data were collected in a stepwise process.

- Collect all non-pigeon dead birds over a 7 day period
- Identify areas of large cluster of dead birds
- Restrict the search to areas where at least one human infection was identified
- Test birds in these areas for the presence of the virus
- Initiate a larvae control program in the areas where positive results were obtained

The strategy was considered successful as measured by the