Expert Judgment Elicitation Methods

This project will develop methods and tools for assessment of threats from terrorism based on probabilistic judgments from multiple experts.

Modeling Area: Risk Assessment
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Brief Description: Expert elicitation of probabilities and probability distributions is often required to quantify risks from terrorist activities. In this project, we will develop advanced expert elicitation tools and provide support with these tools for specific expert elicitation situations encountered in terrorism assessment. Past experience has shown that risk assessment of terrorist activities entails unique elicitation situations that have not been previously studied in other applications of risk assessment. This work will directly support the elicitation of biological threat risks and the elicitation of chem/rad/nuke threat probabilities.

Objectives: The purpose of this project is to develop advanced tools for expert elicitation and to support CREATE's risk assessment through state-of-the-art expert elicitation methods and processes. Recent risk assessment of bio-terror threats has illustrated the need for advanced assessment tools for the uncertainty analysis of split fractions. Work is underway to extend our knowledge and tool set for these situations to provide greater flexibility in developing elicitation protocols and provide protocols that are easier to implement. Work for the upcoming year will entail the development of assessment tools based on binary tree representations of split fractions. The set of uncertainty distributions encoding uncertainty about binary splits will be extended well beyond the current beta family. Methods for combining judgments from multiple experts will be evaluated. Supporting this work is the further development of methods for measuring the performance of aggregation rules for expert judgments given as densities. The central task is to extend performance measures developed for univariate densities to the multivariate domain.

Interfaces to other Center Projects:
This project will interface with all CREATE projects that require expert elicitation, especially in the risk assessment area.

Interfaces to non-Center Projects:
We expect to conduct expert elicitations of probabilities and probability distributions of threats from bio and chemical terrorism and threats from nuclear and radiological agents. The work also supports studies of the safety of nuclear waste disposal strategies.

Major Products and Customers:
The first product is the development of a theoretical basis for the assessment of constrained vectors of probabilities or split fractions. It is anticipated that the assessment of k-variate densities can be accomplished by the assessment of k univariate densities, a much simpler task. It is anticipated that binary tree representations of split fractions will provide the theoretical model upon which these advances are built. The first major product will be methods for implementing the theoretical advances useful in elicitations.

A full understanding of the notions of information, calibration, and expected scores will be extended from univariate assessments to the assessment of constrained vectors. An examination of methods of integrating judgments from multiple experts will be made and a theoretical justification for aggregation of judgments provided. Improved methods for aggregating judgments is the second major product of this project.

Computer programs will be developed in cooperation with Dr. Eppel to assist in the assessment process by providing graphical feedback, alternative assessment questions, automated fitting of k-variate distributions to assessed quantiles, and the assembly of uncertainty distributions for binary splits into multivariate densities and distribution functions for split fractions. This is the third major product.

The theories, methods, and tools developed for elicitation will be use to support CREATE projects in the areas of biological, chemical, nuclear, and radiological threats. The elicitations needed to quantify these risks constitute a third product.

Technical Approach:

It has been established that split fractions can be represented in multiple ways by binary trees. Quantification of these trees through uncertainty distributions allows the use of general densities on [0,1] to be used for quantification rather than k-variate distributions. It has been shown that when beta densities are employed in this manner, the resulting recomposed density is of the Dirichlet family. The methods of mathematical statistics will be employed to extend the set of usable univariate distributions in split fraction quantification.

The principal investigator has been responsible for the development and refinement of the notion of calibration for continuous quantities. This approach will be extended to *k*-variate split fraction distributions. Additionally, the concept of the information in a distribution will be extended to the spit fraction model. These tasks are accomplished using the methods of mathematical statistics. Methods for aggregating multiple distributions will be examined using sequences of distributions have particular properties such as being well-calibrated. The performance of the aggregation methods will be evaluated using the metrics of calibration, information, and expected proper scores.

The theoretical findings will be translated into practical tools using spreadsheets as an interface. Tools for assessment of split fractions will be extended and refined and tools for aggregation of judgments developed.

Major Milestones for 2008-2009:

1. Development of alternative representations of split fractions through binary trees and investigation the relation between the univariate densities used for quantification and the resulting split fraction multivariate density.
2. Extending the concept and calibration and a calibration trace to multivariate densities and applying this extension to split fraction uncertainty distributions.
3. Development of the theoretical structure for evaluating aggregation methods based on performance measures and the application of this structure to the aggregation of Dirichlet densities.