Comment

Peter A. Morris

"Combining Probability Distributions: A Critique and an Annotated Bibliography," by Genest and Zidek provides a review of methodologies for aggregating probabilistic judgments. While I would evaluate the strengths and weaknesses of the different techniques somewhat differently, I found the paper a useful compendium of an assortment of different approaches.

Some of the approaches described are quite interesting, while others appear superficial and somewhat naive. However, it is difficult to review a review paper without performing another review and I'd like to avoid that here. Instead, I'd like to comment on the process of evaluating different expert aggregation methods.

1. PURPOSE OF THE AGGREGATION

I find the most useful way of thinking about the problem of expert aggregation is to view it as helping an individual update his or her state of information based on reception of an expert's advice. These states of information are typically represented with probabilities (or some form of probability statement).

Many of the approaches described in this paper are fuzzy to me in spite of their mathematical precision because they seem to be making an attempt to form an "aggregate opinion." This, in my mind, is an ill defined concept. Probability is a measure of an individual's state of information about an uncertain event. There is no such thing as a "joint state of information." Individuals have opinions; groups do not.

In the rare situation in which each expert in a group shares precisely the same state of information and the same probability distribution, then that probability distribution might reasonably be termed the "opinion of the group." However, when the experts inevitably disagree (even after intensive interaction), any so-called "consensus" or agreement on a distribution is necessarily a group *decision*, not the reflection of a "joint state of information." In particular, there is no logical reason for a group to achieve consensus in their probabilities if they start with different opinions and have different feelings about each other's expertise.

Thus, I believe the problem of aggregation, in order to be well defined, is the problem of updating an individual's state of information based on the reception of a set of expert probabilities. The best we can do is ask for a single individual, "What is the appropriate way to update a prior probability in light of learning about others' probabilities?" I agree with Lindley that other approaches have "an element of adhockery."

Thinking in this way is not only more satisfying conceptually, but provides a device for obtaining physical insights. In evaluating each approach, we can consider the specific assumptions a single individual would have to make in order to combine expert opinions in the proposed way. For example, suppose we are considering a linear weighting formula for combining two weather forecaster's rain probabilities. We can ask specific questions, like: "Does knowledge that one expert's probability of rain is high indicate that it is likely that the other expert's probability will be high as well?" If the answer is "yes" as I think it would be in most cases, then the linear weighting scheme makes no sense.

2. FUNDAMENTAL ISSUES

The discussion in the review article is fairly mathematical, and as such provides good in-depth material for researchers in expert use. However for those who are not "experts on experts," some basic issues in expert resolution may be masked by all the mathematics. In my view there are several fundamental issues that any realistic combination methodology must address (or at least *explicitly* not address) to be viable. Testing against these basic issues often helps determine quickly whether a method is reasonable, and many techniques that appear quite sophisticated fail simple reasonability checks. Four fundamental issues are:

- Nonindependent experts
- Event probabilities and underlying frequencies
- Calibration
- Level at which aggregation is performed

Nonindependent Experts

The issue of nonindependence among experts is critically important because it significantly affects the amount of uncertainty that one associates with the group. It is the single most important issue in practical applications. Yet, it is often ignored in many expert combination formulas, probably because it is extremely difficult to think about, much less quantify.

Peter A. Morris is a Principal with Applied Decision Analysis, Inc., 3000 Sand Hill Road, Building 4, Suite 255, Menlo Park, CA 94025, and a Consulting Associate Professor with the Department of Engineering-Economic Systems at Stanford University.