Optimal Detection and Identification of a Sudden Change in an Information Pattern

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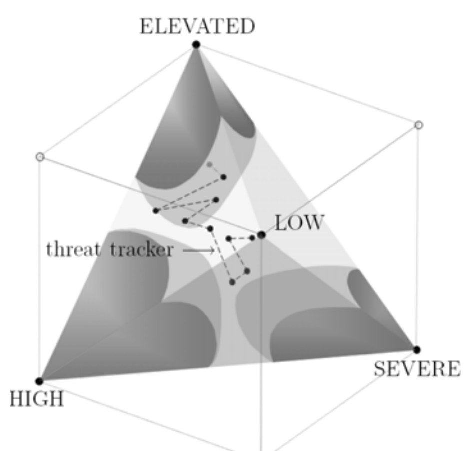
PROJECT DESCRIPTION/SCOPE: We study the joint problem of detection and identification of a sudden and unseen change in the statistical pattern of an information sequence to one of several alternative patterns. The objective is quick detection of the change and accurate inference of the ensuing pattern. This fundamental problem arises in a variety of applications, such as threat detection and identification in national defense and fault detection and isolation in industrial processes.

There are two competing goals associated with addressing this problem effectively. On one hand, we would like to detect the change as soon as it occurs so that we can react quickly. This calls for an on-line approach that can efficiently incorporate the latest information as soon as it is available. On the other hand, we would like to assess the nature of the change so we can react appropriately and use our limited resources effectively. This encourages waiting for more information before reacting. It is important for our decision strategy to balance this inherent trade-off properly. Moreover, although the information sequence bears the signature of the underlying change, typically, the root cause is unseen and we can only *infer* the emergence of an actual threat from the available information with an ever-present risk for getting it wrong. That is, our decision strategy must simultaneously factor in the costs of detection delay, misdiagnosis, and false alarm.



RECENT PROGRESS: Following a Bayesian approach, we reveal a new sequential decision strategy for this problem and provide an optimal mathematical solution. We demonstrate geometrical properties of this strategy via numerical and graphical examples.

For example, suppose that we process an information sequence in order to assess a change in the underlying threat level. Initially the inferred threat is low, but at some unknown and unseen time, the activity changes and the inferred threat changes to one of three prototypical cases, representing an elevated, high, or severe threat. Left is a depiction of the optimal sequential decision strategy for a sample simulation of such an instance showing the tracking of the decision statistic (dotted line) in order to trigger an appropriate new warning level (indicated by it entering a shaded corner of the tetrahedron) and to set in motion the proper measures and resources.

FUTURE WORK: We will address a variety of statistical issues, such as dependence between the change time and its cause and multiple serial changes in the information sequence.