A Perspective on Information Fusion Problems

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Information fusion problems have a rich history spanning four centuries and several disciplines as diverse as political economy, reliability engineering, target tracking, bioinformatics, forecasting, distributed detection, robotics, cyber security, nuclear engineering, distributed sensor networks, and others. Over the past decade, the area of information fusion has been established as a discipline by itself with several contributions to its foundations as well as applications. In a basic formulation of the information fusion problem, each component is characterized by a probability distribution. The goal is to estimate a fusion rule for combining the outputs of components to achieve a specified objective such as better performance or functionality compared to the components. If the sensor error distributions are known, several fusion rule estimation problems have been formulated and solved using deterministic methods.

In the area of pattern recognition a weighted majority fuser was shown to be optimal in combining outputs from pattern recognizers under statistical independence conditions. A simpler version of this problem corresponds to the Condorcet Jury theorem proposed in 1786. This result was rediscovered since then in other disciplines including by von Neumann in 1959 in building reliable computing devices. The distributed detection problem, studied extensively in the target tracking area, can be viewed as a generalization of the above two problems. In these works, the underlying distributions are assumed to be known, which is quite reasonable in the areas these methods are applied.

In a different formulation, we consider estimating the fuser based on empirical data when no information is available about the underlying distributions of components. Using the empirical estimation methods, this problem is shown to be solvable in principle, and the fuser performance may be sharpened based on the specific formulation. The isolation fusers perform at least as good as best component, and the projective fusers perform as good as best combination of components. In a special case of function estimation, each component could be a potential function estimator, radial basis function, nearest neighbor estimator, regressogram, kernel estimator, regression tree or another estimator.

A projective fuser based on a nearest neighbor concept has been proposed based on Voronoi regions in this case. Under fairly general smoothness and non-smoothness conditions on the individual estimators, the expected fuser error is close to optimal with a specified probability. This result is purely sample-based and distribution-free in that it does not require the knowledge of underlying distributions and can be computed only using measurements.

**Keywords** Information fusion; Empirical estimation; Distributed detection; Isolation fuser; Projective fuser

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