Soft Computing for Sensor and Algorithm Fusion

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Abstract

Sensor and algorithm fusion is playing an increasing role in many application domains. As detection and recognition problems become more complex and costly (for example, landmine detection and automatic activity monitoring), it is apparent that no single source of information can provide the ultimate solution. However, complementary information can be derived from multiple sources. Given a set of outputs from constituent sources, there are many frameworks within which to combine the pieces into a more definitive answer. This talk will focus on the fusion of multiple partial confidence values within the framework of fuzzy set theory.

So, the question then becomes: what methodology do we use to combine partial decision information? There are many choices, but I will focus on the use of fuzzy set theoretic mechanisms to fuse confidence from multiple sources. Two general approaches will be considered, fuzzy integrals and fuzzy logic rule-based systems. Fuzzy integrals have a long history and have been studied in the context of pattern recognition and information fusion for several years being first introduced for this purpose by Tahani and Keller in 1990. Fuzzy integrals combine the objective evidence supplied by each information source with the expected worth of each subset of information sources (via a fuzzy measure) to assign confidence to hypotheses or to rank alternatives in decision making. This is a nonlinear combination of information and the worth of the information for the decision in question, dealing with the uncertainty in both forms of data. Different fuzzy measures yield different integration operations, including averaging, linear combinations of order statistics, and many others. Measures can be found by heuristic assignment or via training algorithms. Results with discriminative training will be discussed. Next, a fusion system based on a linguistic extension of the Choquet fuzzy integral will be shown. The uncertainty in the data is now expressed as a linguistic vector, i.e., a vector of fuzzy sets. The linguistic Choquet integral is used to fuse both position and confidence uncertainty in the landmine detection scenario.

Fuzzy logic rule-based systems provide another mechanism to fuse together the results of different features, classification algorithms and sensors. Such a system employs rules much like those that a human expert might derive. Again, uncertainty in the component parts is modeled by linguistic variables taking on fuzzy sets as values. If time permits, I will describe the application of fuzzy rule-based classifiers in image processing and/or landmine detection and/or fall detection in an Eldercare environment.