DYNAMIC AND ACTIVE INFORMATION FUSION FOR DECISION MAKING UNDER UNCERTAINTY

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ABSTRACT

In recent years, there has been a great deal of interest in information fusion for both military and civilian applications. As sensors become ubiquitous and distributed, and they are used for increasingly complex applications, there is an ever-increasing demand for efficient use of time and resources. Consequently, it is critically important to perform fusion in a timely and efficient manner. Active fusion serves this purpose well. Active fusion extends the paradigm of information fusion, being not only concerned with the methodology of combining information, but also concerned with the fusion efficiency, timeliness, and accuracy. By purposively choosing an optimal subset from multiple sensory sources, it can save computational time and physical cost, reduce redundancy, and improve decision-making performance.

This thesis aims to solve the following technical challenges in active fusion for timely decision-making. The first one is problem modeling. For this purpose, we propose a unified framework based on influence diagrams for simultaneously modeling sensor selection, sensor fusion, and decision making. Given the framework, the second challenge is model parameter learning. For this purpose, we propose a constrained Expectation-Maximization (CEM) learning algorithm to automatically estimate the model parameters when training data are incomplete or sparse. Given the model and the learned parameters, the third challenge is to perform efficient sensor selection and efficient information fusion. There are three key issues here: sensor selection criterion computation, optimal sensor-set selection, and efficient fusion. For the first issue, we propose an approximation algorithm to efficiently compute non-myopic value-of-information as a sensor selection criterion. For the second issue, two efficient sensor-selection algorithms are proposed to choose the optimal sensor sets under two typical scenarios: the budget-limit case and the optimal-tradeoff case. For the third issue, a factor-tree inference (FTI) algorithm is proposed to efficiently fuse the information collected from the selected sensors. Finally, to demonstrate the proposed framework and algorithms, we apply them to two applications: multistage battlefield situation assessment, and human affect recognition and assistance.