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Weighted Sensor Attributes Fusion Based on OWA in Heterogeneous Sensor System

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Abstract: In order to leverage discrepancy of Sensor for attributes fusion in Heterogeneous Sensor System, Weighted Sensor attributes Fusion Based on OWA (Ordered Weighted Averaging) operators is proposed, in which attributes collecting from various sensors would be transformed according to sensor Weights and then attribute Fusion should be performed with normalized attributes, which would improve performance for attribute Fusion in Heterogeneous Sensor System and guide decision making in target recognition. Furthermore, an illustrative case study is given to validate our proposed techniques.

Key words: Attributes fusion, weighted sensor, OWA operators, target recognition

INTRODUCTION

Recent advances of sensor techniques have enabled development of heterogeneous sensor system that composed of many sensor nodes with different capability and speciality. Hence, samples collected by theses sensors should not be treated equally.

Weighted Sensor attribute Fusion developed from information fusion is a process of combining relevant attribute from heterogeneous sensor nodes into a more informative attribute according to sensor weights.

There are many classical multi-information fusion technologies such as Bayesian Inference (Sommer *et al*., 2009) and Kalman Filter (Gan and Harris, 2001). Especially, the OWA (Ordered Weighted Averaging) operator proposed by Yager (1992, 1993) is an aggregation technology for multi-attribute information fusion between maximum and minimum operators. In recent years, researches in relation to OWA operator have been paid much attention to and OWA operator have applied in many fields of decision making (Xiong and Fu, 2010; Wei *et al*., 2009; Torra, 1996). However, existing attribute fusion methods are only focus on attribute values collecting from same sensors. Practically, there are many sensor systems without same sensor nodes, especially in heterogeneous sensor system, in which different sensor nodes have different quality and performance. And they have different weights when attribute fusion for multi-sensor.

Consequently, we propose a more accurate model for attribute fusion in heterogeneous sensor system, in which attributes collecting from heterogeneous sensor nodes would be normalized according to sensor weights and then fused into informative attribute for target recognition or classification.

OWA OPERATOR

An n-dimensional OWA operator is a mapping F: Rn→R that has an associated weighting vector $W = (w_{1,}\ w_{2,}\ ...w_n)^T$ having following properties:

$$w_1+w_2+...w_n = 1,\ 0\le wi\le 1, i = 1,...n$$

And such that:

$$F(a_1, a_2, \cdots a_m) = \sum_{i=1}^{n} w_i b_i \quad (1)$$

where, b_j is the *jth* largest element of the collection of aggregated objects $\{a_{1,}\ a_{2,}\ ...a_m\}$.

WEIGHTED SENSOR ATTRIBUTE FUSION USING OWA

Multi-sensor attribute fusion has widely used to state estimation and target recognition. Figure 1 shows the architecture of attribute fusion in heterogeneous sensor system.

WEIGHTED SENSOR ATTRIBUTES FUSION MODEL

Define T = {A1, A2,… Am} as a collection of the probable decision-making problem in heterogeneous sensor system, S = {S1, S2,… Sn} as a collection of sensors. And the element $a_{ij}\epsilon[0, 1]$ in relationship matrix $R_{T\times S}$ indicates the probability of decision making being A_m from sensor S_n.

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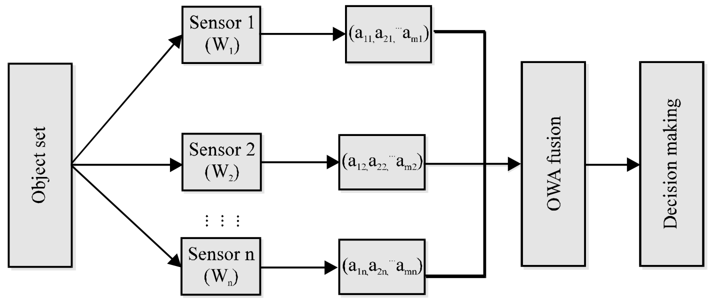

Fig. 1: Architecture for attribute fusion in heterogeneous sensor system

Formally, matrix $R_{T\times S}$ is defined in the following:

$$R_{T\times S} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \vdots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix}$$

Accordingly, weighted sensor attributes Fusion model is defined as:

$$\begin{aligned} & R_{decision-making} \\ & = R_{T\times S} \times W \\ & = \begin{bmatrix} r_1 \\ \vdots \\ r_m \end{bmatrix} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \vdots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \times \begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix} \end{aligned} \quad (2)$$

More formally, target is decided according to the following rules:

$$\text{target} = A_j \text{ such that } r_j = \max\{r_1, r_2, \cdots r_m\} \quad (3)$$

ACTIVE OWA OPERATOR

It is critical to determine OWA operator weights for applying OWA operator in decision making. There are a number of approaches have been suggested for obtaining associated weights (Fuller, 2007), such as quantifies guided aggregation (Yager, 1988), earning (Xu and Chen, 2007) and exponential smoothing (Sadiq and Tesfamariam, 2007). In this paper, we introduce an active index for user-defined OWA operator weights based on exponential OWA operator.

Definition 1: F_w is an OWA operator with weighting vector $W = (w_1, w_2, \ldots w_n)^T$, hence active index (AI) is defined as:

$$AI(W) = \frac{1}{n-1}\sum_{i=1}^{n}(n-i)w_i = \alpha$$

where, $\alpha\in[0,1]$ and decision-maker is more optimistic or active when AI (W) is more close to 1.

Definition 2: Define active OWA operator weights as follows:

$$\begin{aligned} & w_1 = \alpha \in [0,1] \\ & w_2 = \alpha(1-\alpha) \\ & \cdots\cdots\cdots \\ & w_{n-1} = \alpha(1-\alpha)^{n-2} \\ & w_n = \alpha(1-\alpha)^{n-1} \end{aligned}$$

CASE STUDY

Consider a heterogeneous sensor system composed of five groups of sensor. And a target A_1, A_2, A_3, A_4 and A_5 respectively represents five different types of plane.

Assuming that their reliability is known: the first sensor group (or the best sensor group) is twice reliable than the second-best sensor group and the third group is half reliable than the second-best sensor group. This corresponds to: $\alpha = 0.5$. So sensor weighting vector is:

$$W_{plane} = \begin{bmatrix} 0.5 \\ 0.25 \\ 0.125 \\ 0.0625 \\ 0.03125 \end{bmatrix} \quad (4)$$

The original decision probability of targets acquired from weighted sensors is presented in Table 1. According to Table 1, the relationship matrix $R_{T\times S}$ for plane recognition is:

$$R_{T\times S_{plane}} = \begin{bmatrix} 0.453 & 0.162 & 0.091 & 0.124 & 0.170 \\ 0.369 & 0.168 & 0.089 & 0.118 & 0.256 \\ 0.208 & 0.117 & 0.154 & 0.406 & 0.115 \\ 0.193 & 0.418 & 0.119 & 0.235 & 0.035 \\ 0.187 & 0.151 & 0.445 & 0.113 & 0.104 \end{bmatrix} \quad (5)$$

Table 1: Targets detected from weighted sensors

		Probabilities				
Sensor	Sensor weights	A_1	A_2	A_3	A_4	A_5
S1	0.5	0.453	0.162	0.091	0.124	0.170
S2	0.25	0.369	0.168	0.089	0.118	0.256
S3	0.125	0.208	0.117	0.154	0.406	0.115
S4	0.0625	0.193	0.418	0.119	0.235	0.035
S5	0.03125	0.187	0.151	0.445	0.113	0.104

Table 2: Targets detected from weighted sensors

	Probabilities					
	Normalized probabilities with sensor weights					
Targets	S_1	S_2	S_3	S_4	S_5	Decision probabilities
A_1	0.227	0.092	0.026	0.012	0.006	0.363
A_2	0.081	0.042	0.015	0.026	0.005	0.168
A_3	0.046	0.022	0.019	0.007	0.014	0.108
A_4	0.062	0.030	0.051	0.015	0.004	0.160
A_5	0.085	0.064	0.014	0.002	0.003	0.169

According to Eq. 2, normalized probabilities with sensor weights would be computed as follows:

$$R_{decision-making_{plane}} = R_{T\times S_{plane}} \times W_{plane} \qquad (6)$$

According to Eq. 6, normalized probabilities with sensor weights for different plane and decision probabilities could be normalized, as detailed in Table 2.

Consequently, the best alternative plane is A1 according to the decision-making rules as shown in Eq. 3.

CONCLUSION

Heterogeneous sensors would be widely equipped in sensor network system with development of sensor technologies, so information fusion in Heterogeneous sensor system should take not only attribute values but also sensor weights into account for targets recognition. Accordingly, weighted sensor attributes fusion based on OWA operators is proposed, which would leverage discrepancy of sensor for attributes fusion and improve reliability in Heterogeneous sensor systems. Furthermore, illustrative case study presented could validate weighted Sensor attributes fusion based on OWA operators.

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REFERENCES

Fuller, R., 2007. On obtaining OWA operator weights: A short survey of recent developments. Proceedings of the IEEE International Conference on Computational Cybernetics, October 19-21, 2007, Gammarth, pp: 241-244.

Gan, Q. and C.J. Harris, 2001. Comparison of two measurement fusion methods for Kalman-filter-based multisensor data fusion. IEEE Trans. Aerospace Electron. Syst., 37: 273-279.

Sadiq, R. and S. Tesfamariam, 2007. Probability density functions based weights for Ordered Weighted Averaging (OWA) operators: An example of water quality indices. Eur. J. Oper. Res., 182: 1350-1368.

Sommer, K.D., O. Kuhn, F.P. Leon and B.R.L. Siebert, 2009. A bayesian approach to information fusion for evaluating the measurement uncertainty. Rob. Auton. Syst., 57: 339-344.

Torra, V., 1996. Weighted QWA operators for synthesis of information. Proceedings of the 5th IEEE International Conference on Fuzzy Systems, September 8-11, New Orleans, LA., USA., 1996, pp: 966-971.

Wei, C.F., Z. Pei and B. Li, 2009. Multiple attribute decision making based on induced OWA operator. Proceedings of the IEEE International Conference on Fuzzy Systems, August 20-24, 2009, Jeju Island, pp: 1763-1766.

Xiong, G.Q. and W.L. Fu, 2010. An information fusion technology based on fuzzy-owa operator. Proceedings of the 7th International Conference on Fuzzy Systems and Knowledge Discovery, August 10-12, 2010, Yantai, Shandong, China, pp: 1190-1194.

Xu, Z.S. and J. Chen, 2007. An interactive method for fuzzy multiple attributes group decision-making. Inform. Sci., 177: 248-263.

Yager, R.R., 1988. On ordered weighted averaging aggregation operators in multicriteria decision making. IEEE. Trans. Syst. Man Cybernet, 18: 183-190.

Yager, R.R., 1992. Applications and extensions of OWA aggregations. J. Man-Mach. Stud., 37: 103-132.

Yager, R.R., 1993. Families of OWA operators. Fuzzy Set Syst., 59: 125-148.