Data fusion of priority information using a Dempster combination rule

뎀스터 결합규칙을 이용한 우선순위 정보의 결합: 방폐물 처분장의 방출시나리오

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Keywords: Dempster rule of combination, evidence fusion, belief function, plausibility function, Choquet integral, fuzzy measure, fuzzy integral.

Generally, in the science and engineering areas, there has been a need to integrate various data resulting from independent sources of information (e.g., different groups, algorithms, or methods). In the present study, to combine multiple pieces of information on priority values of decision alternatives determined by various sources of knowledge (i.e., different aggregation methods such as weighted arithmetic method, belief-based Choquet integral, and plausibility-based Choquet integral), the Dempster method based on the Dempster's rule of combination [1; 2; 3] is proposed.

As a case study, a multiple criteria decision-making problem, a ranking of radionuclide release scenarios in a low and intermediate radioactive waste repository [4], is taken into account. The ranking in terms of a relative degree of priority of scenario alternatives enables us to incorporate more effective safety measure in a design stage of the repository. To illustrate a proposed methodology for updating ranking priority of release scenarios, priority information from three individual methods as well as the combined Dempster method is compared. Three types of methods [5] to be combined are as follows: 1) the weighted arithmetic mean (WAM) method, a linear aggregation of a preference score matrix and a weighting vector is based on the no-interaction among criteria. The weighting vector is viewed as additive probability measures. The WAM method is bound to be equivalent to an AHP model; 2) the belief-based Choquet integral (BCI) method represents the pessimistic attitude towards aggregation using the synergistic interaction among criteria; 3) the plausibility-based Choquet integral (PCI) method leads to the optimistic assessment along with the inhibitory interaction among criteria. The finite frame of discernment, all the possible states of the problem under consideration, is Θ={WAM, BCI, PCI}. The framework of the Dempster combination rule is depicted in Figure 1 for three sources of evidence such as the WAM model {WAM}, the belief model {BCI}, and the plausibility model {PCI}.

Table 1 shows the priority scores and rankings obtained from three individual methods. It should be noted that they are normalized for data fusion and regarded as basic probability assignments at the combination stage. Table 2 shows the priority scores and rankings yielded from four combined methods using a Dempster rule of combination. Here, the operator $\oplus$ for two mass functions is an orthogonal sum and is both commutative and associative. The conflict measure for WAM$\oplus$BCI$\oplus$PCI( ) amounts to around 0.76. It is found that the priority scores and ranking orders are affected after the data fusion among independent sources of information such as WAM( ), BCI( ), and PCI( ). Thus, it suggests that the priority ranking among release scenario alternatives be dependent upon the applied

decision analysis methods. For the combination rule to be more practically applicable, the interpretation of the combined results is further to be studied.

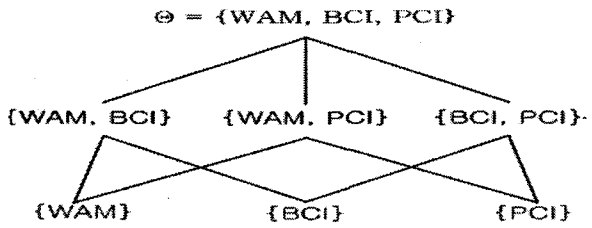

Figure 1: Structure of Dempster-Shafer theory

Table 1: A degree of priorities of the individual methods for each release scenario

Individual method / Scenario alternative	WAM method	BCI method	PCI method
S_1	0.2914 (1)	0.2609 (2)	0.4118 (1)
S_2	0.2535 (2)	0.3625 (1)	0.1556 (3)
S_3	0.1454 (4)	0.1345 (3)	0.1113 (5)
S_4	0.1441 (5)	0.1164 (5)	0.1248 (4)
S_5	0.1656 (3)	0.1257 (4)	0.1965 (2)

Notes: The number in () denotes the priority ranking.

Table 2: A degree of priorities of the combined Dempster methods for each release scenario

Combined method / Scenario	WAM⊕BCI	WAM⊕PCI	BCI⊕PCI	WAM⊕BCI⊕PCI
S_1	0.3378 (2)	0.5306 (1)	0.4927 (1)	0.5801 (1)
S_2	0.4083 (1)	0.1745 (2)	0.2587 (2)	0.2650 (2)
S_3	0.0869 (4)	0.0715 (5)	0.0687 (4)	0.0403 (5)
S_4	0.0745 (5)	0.0796 (4)	0.0666 (5)	0.0388 (4)
S_5	0.0925 (3)	0.1438 (3)	0.1133 (3)	0.0758 (3)

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