Abstract

Attitudinal Choquet integral (ACI) is a recent aggregation operator that considers in the aggregation process the criteria interaction and the DM’s attitude, both of which are specific to the decision-maker. However, this capability comes at the cost of increased complexity that hinders its applicability in big data analytics. To address the same, in this paper, we explore some Heuristics-based models for the ACI operator so as to somehow overcome its complexity. We devise new and efficient forms of ACI, and test their validity in the real world datasets, against the backdrop of preference learning.

Index Terms Attitudinal Choquet integral; efficiency; complexity; reduction; attitudinal character; multi-criteria decision making.

Methods and Materials

We use the real datasets in our experiments, which are available in UCI and Weka repositories. Since monotonicity is a basic property in all the aggregation operators, all the chosen datasets are monotone in the sense that “the more the better”.

Experiment Steps

We implement weighted averaging (WA), Choquet integral (CI), ACI and finally our heuristic methods on a set of nine datasets shown in Table I by performing the following steps:

1) Given a set of attributes, A, two halves are created, namely A train and A test, for training and testing, respectively.
2) The training information is provided in terms of the pairwise preference pairs of the form (a+b) are identified through the standard method of random sampling from Atrain.
3) The number of preferences are taken as N = 1000. For a healthy comparison, the same set of random preferences is provided to different methods, in each iteration.
4) With different approaches, different learning models are induced on the given preference pairs.
5) The ranks of the given alternatives in Atest are predicted through WA, CI, and ACI methods.
6) The corresponding prediction accuracies are evaluated by comparing the predicted ranking for Atest against the ground truth ranking.
7) For each method, the prediction accuracy is computed by considering the degree of match between the predicted and ground truth ranks.

The scoring function $U(a)$ helps to predict the rank of an alternative $a$.

The discrete Choquet integral $6,18,21$ is an aggregation function that considers varying degree of interaction among the criteria. The criteria can interact positively, indicating synergetic or desirable combination; or negatively indicating redundancy or undesirable combination. For instance, while making a choice of house, the criteria size and location are complementary, and hence interact positively, luxury and size may interact negatively for a buyer who is looking for a luxurious but small house. It is shown in 11,14 that most of the extant aggregation operators are the special cases of it. It has been applied in policy capturing in strategic decision making.

The proposed version heuristic form of ACI offers an unique provision to obtain optimal parameters quickly while preserving the basic advantages of the ACI operator. The proposed approach is developed so as to reduce the complexity in each step, and to have an overall more favorable optimization settings which together lead to finding a better solution efficiently overcoming the complexity of the ACI in its original form. It is also notable that in the original ACI setting, the solver is burdened with an exponential number of constraints, which naturally affects the quality of the solution obtained. The proposed form imports simplicity to the optimization process that can be carried out conveniently resulting in an overall better performance both in terms of the results as well as the time required. It is also interesting to note that despite a large number of attributes (as the case in some of the chosen datasets), our approach displays almost linear characteristics. Lastly but perhaps more importantly, the weights derived from the proposed approach obey monotonicity property that makes it very much desirable in most of human decision making applications.

As a future work, it would be useful to develop the measures such as Shapley index, interaction index and specifically fuzzy measure for the proposed form of ACI. Besides, it would also be good to investigate the application of the proposed form of ACI and such measures in a human decision making problem.

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References


Table I. Data sets and their properties

<table>
<thead>
<tr>
<th>Dataset</th>
<th>z</th>
<th>BCC</th>
<th>CEV</th>
<th>ERA</th>
<th>LEV</th>
<th>I</th>
<th>ACI</th>
<th>ACI, add</th>
<th>ACI, sub</th>
<th>ACI, full</th>
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</thead>
<tbody>
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<td>5</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
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<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Employee Selection (ESL)</td>
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<td>5</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Acceptance(ERA) Lecturers Evaluation (LEV)</td>
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<td>4</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Table II: Error in terms of the average $C$-Index ± standard deviation.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Mean $C$-Index</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto MPG</td>
<td>0.50 ± 0.02</td>
<td>0.06 ± 0.01</td>
</tr>
<tr>
<td>CPU</td>
<td>0.50 ± 0.02</td>
<td>0.06 ± 0.01</td>
</tr>
<tr>
<td>Employee Selection (ESL)</td>
<td>0.50 ± 0.02</td>
<td>0.06 ± 0.01</td>
</tr>
<tr>
<td>Acceptance(ERA) Lecturers Evaluation (LEV)</td>
<td>0.50 ± 0.02</td>
<td>0.06 ± 0.01</td>
</tr>
</tbody>
</table>

Table III: Runtime reported in milliseconds.