An Exploration of Experts' Subjective Patterns in Behavioral Based Job Qualification Using Choquet Integral

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Abstract: - In this paper, the experts' views about the merit of individuals in a specified job based on behavioral features are gathered and used as training data for a Choquet approximator. By adjusting fuzzy measures, the approximator gains the ability to emulate the role of expert in assigning a merit score to a set of behavioral features. Shapley and interaction indices computed based on fuzzy measures and can partially discover the experts' subjective patterns in job qualification process.

Key-words: Choquet integral, pattern recognition, Interaction index, behavioral feature, Fuzzy Measures

1 Introduction:
In many kinds of problems, we use experts' views and opinions to achieve to an acceptable solution. It means we ask their opinion about the case and after elimination of deviations; we would trust to and execute their opinions. In the field of human resource Management (HRM), there are many kinds of these judgment based on experts views. Job assignment is one of these problems especially when we do it base on behavioral features and we had studied it. In this study we had faced to four main questions about experts' view and pattern in assignment of individuals to a specific job base on behavioral features as follows:
1- What is their pattern in doing so?
2- Can we learn this pattern an emulate it?
3- Is there any interaction exist between criteria of these decision making process? (here behavioral features)
4- Can we determine the effect (weight) of each criterion on the final result of expert decision?

Although these kinds of problems are so important and many models have been developed about them, but there is a lack of artificial intelligence models in this field.
In this paper we aimed to use a fuzzy integral concept to model experts' views and their subjective pattern in assignment individuals to a specific job based on behavioral features.
This paper has three basic objectives:
1- modeling experts' views and subjective patterns in assignment on individual to a specific job.
2- Determining the interaction between behavioral features and discovering the probable existence of synergy and redundancy of these features based on experts' subjective pattern in assignment process.
3- determining the effect (weight) of each of these behavioral features on the final score of relevant individual.
In order to achieve these objectives, first we had choose some applicant for a specific job and evaluate four behavioral features of them through relevant behavioral tests. In table 1 these behavioral features and the ability of each index are introduced.

<table>
<thead>
<tr>
<th>Behavioral feature</th>
<th>Abilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligence</td>
<td>Ability to classifying objects, logical relations between issues, determine geometrical conditions and compatibility with new and innovative situations</td>
</tr>
<tr>
<td>Precision</td>
<td>Ability to detect similarities between pictures and Ability to more quick conformity on simple issues</td>
</tr>
<tr>
<td>Memory</td>
<td>Ability to memorize a great amount of information, remember stored information and quickly memorize required information</td>
</tr>
<tr>
<td>Creativity</td>
<td>Ability to find solutions, ideas and making new innovative concepts</td>
</tr>
</tbody>
</table>

Table 1. Behavioral features

In this regard every applicant obtains the score on a 100 basis. Since we need to get these results to expert to make them comparable, categorize the final score to five lingual variables, ranging from very low to very high. Then the results was given to expert and asked them to interpret every individual for a specific job. For example the said specialist was asked to declare what is the extent of merit of every individual, regarding to be assigned to a specific job. So, different combinations of behavioral feature as well as the five lingual variables, bearing the judgment of the experts. An example is given here:

If Intelligence is Very high & Precision is High & Creativity is very high & Memory is very low then what is the result of merit?

In table 2 some of the results of this evaluation are shown. In this table the four first columns shows the behavioral feature and the last column shows the judgment of expert.

<table>
<thead>
<tr>
<th>Behavioral feature</th>
<th>Person</th>
<th>Intelligence</th>
<th>Precision</th>
<th>Memory</th>
<th>Creativity</th>
<th>Expert's judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
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<tr>
<td></td>
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<td>1</td>
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<td>5</td>
<td>2</td>
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<td></td>
<td>3</td>
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<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 2. Behavioral features test results & scores

Due to four mentioned objectives of this paper, we have used the concept of fuzzy measures, Choquet integrals and Shapley index.

2 Modeling

Sugeno proposed the first notion of fuzzy measure and fuzzy integral in 1974 [1]. The field of crisp measures and crisp integrals is a very important field in mathematics with many applications in areas like engineering. The additivity of a crisp measure whilst being its fundamental property is also a source of inflexibility. There exists however the concept of fuzzy measure [2] where the additivity propriety has been replaced by a monotonicity condition – a weaker requirement. An important aspect of determining fuzzy measures is that they can provide weights for representing synergy and redundancy between criteria (in our case of behavioural features).

2.1 Definition of Fuzzy Measures

Let \( N \) be a set of interacting criteria \( N = \{1,2,...,n\} \), and \( \mathcal{P}(N) \) the power set of \( N \). A function \( \eta : \mathcal{P}(N) \to [0,1] \), is called a fuzzy measure if [3]:

\[
\eta(\emptyset) = 0, \quad \eta(N) = 1
\]

\[
T \subseteq S \subseteq N \Rightarrow \eta(T) \leq \eta(S)
\]

The difference between this measure and the classical, crisp measure is the fact that in a fuzzy measure the additivity property –

\[
\eta(T \cup S) = \eta(T) + \eta(S) - \eta(T \cap S)
\]

– of a crisp measure has been relaxed, originating a weaker requirement [1].

2.2 Definition of Choquet Integral

Fuzzy integrals are generally defined as operators on \([0,1]^n\), the definition presented here will be restricted to the case where \( n = 1 \) [1].

The so-called Choquet integral was first presented by Murofushi and Sugeno [2, 4] using a function defined by Choquet in the capacity theory [1, 5] and is defined as [3]:

\[
C_\eta(x_1, ..., x_n) = \sum (\eta(A_i) - \eta(A_{i+1})) \cdot x_i
\]

Where \( (\cdot) \) indicates a reordering for the elements \( x_i \) such that \( 0 \leq x(1) \leq ... \leq x(n) \leq 1 \), \( A(i) = \{i, ..., n\} \) and \( A(n+1) = \emptyset \), \( \eta \) being a fuzzy measure.
2.2.1 Role of Fuzzy Measure in Choquet Integral

Let $\eta$ be a measure defined in $N$, a set of criteria. In the context of fuzzy integrals, $\eta$ is supposed to represent the importance that different subsets of $N$ should take in the final result [5]. If $N$ has $n$ elements, then the values of the measure $\eta$ must be determined for the $2^n$ possible subsets of $N$, a task that might prove to be difficult for high values of $n$ [5]. Moreover, Grabisch states two important considerations to have in mind when choosing a fuzzy measure to use with a fuzzy integral [5]: first, the global importance of an element $i \in N$ is not only determined by $\eta(\{i\})$ but also by all $\eta(A)$ such that $\{i\} \subset A$; the same question is posed for larger sets of criteria.

2.2.2 Identification of Fuzzy Measures

A very important point in this context is how to determine the measure to be used with a fuzzy integral, i.e., how to determine the $2^n$ coefficients of the fuzzy measure $\eta$. Grabisch presents three approaches [5]: identification based on semantics, identification based on learning data and a combination of both. Assuming learning data is available, the coefficients of the fuzzy measure can be considered parameters, and its values can be obtained via the minimization of a certain error criterion. In this context, the fuzzy integral can be considered a system. Supposing that learning data $(z_k, y_k), k = 1, ..., l$ exists, where $z_k = (z_{k1}, ..., z_{kn})$ represents a vector of inputs, and $y_k$ is the expected evaluation for $z_k$. The parameters can be obtained by minimizing [5]:

$$E^2 = \sum_{k=1}^{l} \left[ C_{\eta} (z_k) - y_k \right]^2$$

(4)

The solution of such equation can be performed with a wide variety of optimization algorithms such as GA, Gradient Descent and others. In the current work the modified Grabisch algorithm [6] has been used to perform the solution.

2.3 Shapley and interaction indices

An important notion for the interpretation of fuzzy measures is the one of Shapley and interaction indices. For any $i \in N$, the Shapley index of $i$ is defined by [5]:

$$\phi_i = \sum_{K \subseteq N - \{i\}} \frac{(n - |K| - 1)!}{n!} \left[ \eta(K \cup \{i\}) - \eta(K) \right]$$

(5)

The summation of all Shapley indices equal zero and can be interpreted as the overall importance of its criterion.

The concept of interaction is a logical extension of Shapley index for a pair of elements $i, j \in N$ and defined by [5]:

$$I_{ij} = \sum_{K \subseteq N - \{i, j\}} \frac{(n - |K| - 2)!}{(n - 1)!} \left[ \eta(K \cup \{i, j\}) - \eta(K) \right] - \eta(K \cup \{i\}) - \eta(K \cup \{j\}) + \eta(K)$$

(6)

It represents the synergy between interacting criteria $i, j$ if positive and redundancy if negative.

2.4 Model Framework

As it determined above, we first aim to correlate multi inputs to a single output. For any specific individual we have 4 behavioural features and also a final score (merit of an individual in a specific job). Choquet integral as a nonlinear integral is used to correlate individuals' features to their score instead of an expert. It means by using a set of training data (real data set in which an expert evaluate behavioural scores of each individual and assign a merit score to him/her), we tried to emulate expert's pattern. By adjusting fuzzy measures, Choquet integral has been trained. Figure 1 shows the conceptual framework of this model.
After completing the training iterations, interaction indices and Shapley index have been calculated. The result of this procedure is shown in next section.

3 Model Results and Interpretations

According to evaluate training process we must use a criteria. Here we use SSE\(^1\) and MSE\(^2\). The SSE of this training process was 0.1138 and the MSE was 0.0018. Figure 2 shows the convergence diagram of training with respect to SSE.

![Fig.2 Convergence Diagram](image)

In any iteration of training process, the desired output of each data set has been compared to Integral output and based on this, error criteria has been calculate and then fuzzy measures are recalculated. Figure 3 shows the final comparisons of desired output and output of Choquet approximator.

![Fig.3 Desired Output vs. Approximator Results](image)

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>precision</th>
<th>Memory</th>
<th>Creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intelligence</td>
<td>1</td>
<td>0.1353</td>
<td>-0.2073</td>
</tr>
<tr>
<td>precision</td>
<td>0.1353</td>
<td>1</td>
<td>-0.0921</td>
</tr>
<tr>
<td>Memory</td>
<td>-0.2073</td>
<td>-0.0921</td>
<td>1</td>
</tr>
<tr>
<td>Creativity</td>
<td>-0.1582</td>
<td>-0.0852</td>
<td>0.2639</td>
</tr>
</tbody>
</table>

Table 3. Interaction Indices

By using Shapley index concept, we can calculate the weight (effect) of each following behavioural features on final score (from expert point of view). The result of this calculation is presented in Table 4.

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>precision</th>
<th>Memory</th>
<th>Creativity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weights</td>
<td>0.3473</td>
<td>0.0800</td>
<td>0.359</td>
</tr>
</tbody>
</table>

Table 4. Shapley Indices

4 Conclusions

In this paper we have tried to apply the concept of nonlinear integral in a behavioural pattern recognition problem. After that, by using a Choquet integral as a non additive aggregation operator and the concept of interaction and Shapley indices, the existence of synergy and redundancy of behavioural features in the final merit score of an individual about a specific job is calculated form an expert point of view. Also the effect of each criterion on final score is calculated.

The interpretation of the results shows that an expert considers a complex pattern in evaluating merit of each individual.

References:


