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A Comparative Analysis of Manual and Computer-Aided Ranking Tasks for Curriculum Development

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Abstract

Inconsistencies in judgement during a manual ranking task can prevent the clear identification of underlying (ranking) policy. AHP (analytical hierarchy process) provides an alternative to overcoming this problem. This study examines these methods in the context of IS curriculum development for their ability to accurately capture the policies of twenty-eight judges. A cluster analysis based on the rankings identifies their underlying policies, and thereby suggests the core courses for the curriculum. The results demonstrate the AHP's ability to capture more consistent ranking policies, and thereby produce clusters of higher predictive quality.

Introduction

A problem facing cluster analysis is the reliability of data. When data contain errors and noise, the clusters may be less distinguishable, or the components forming the bases for the clusters may be incorrect. The problem becomes evident when the data represent the case rankings of several judges. When judges are assigned the task of ranking a set of cases (e.g. candidates, products, etc.), they apply predefined criteria or a ranking policy to determine the acceptability of the case. However, as the number of cases and/or case attributes increases, task complexity increases and the rankings become more susceptible to the inconsistent application of policy. Consequently, this introduces undesirable noise and error into the data, and affects the formation of the clusters.

A computer-based alternative, analytical hierarchy process (AHP), may provide a means for reducing inconsistencies in the rankings, and cleanly capturing the policies. Rather than ranking the cases, judges state *a priori* the degree of their preference for attributes used to evaluate the cases in a series of pairwise comparisons. Weights are eventually assigned to the attributes and an objective function is established. A consistency factor for the function, similar to R-square in regression, suggests its predictive quality. Rankings can be derived by applying the cases to the objective function. With fewer errors and less noise, the rankings should more accurately reflect the judge's ranking policy. However, AHP's shortcomings have been noted (Belton and Gear, 1983), (Saaty and Vargas, 1984), (Troutt and Crenshaw, 1984).

The purpose of this study is to compare a manual and computer-aided method for ranking candidates, and to examine their ability to accurately capture the ranking policies of the judges. The rankings will be used in a cluster analysis to identify the number of common policies present. This study employed the two tasks in the context of information systems (IS) curriculum development. The first required judges to examine a set of IS candidate profiles, and rank them on their employment desirability. In the second, a computer-generated matrix allowed judges to specify their preference to the attributes appearing on the profiles.

Review

A problem faced by judges involved in a manual rank task is the management of information. As the complexity of the task increases, judges lose their ability to track and correctly process information. Several studies have examined this phenomenon, and attribute this demise to information load. Information load has been a recognized problem associated with manual ranking tasks. Increases in the number of attributes that need to be considered for each profile and/or the number of cases that need to be judged place an increased demand on the information processing ability of the judge (Jacoby, 1977), (Miller, 1956), (Milord and Perry, 1977), (Wright, 1974). Beyond an optimal point, a high information load condition arises, decision quality degrades and the decision-maker becomes dysfunctional (Malhotra, 1982). Thus, finite limits on the amount of information an individual can assimilate and process exist (Miller, 1956), (Jacoby, 1977). Wright (1974) observed two information processing differences between decision-makers functioning under conditions of high information load and those operating at optimal processing levels: most accentuated the negative aspects while deriving their decisions, and most tended to overlook attributes that they normally would have considered under less taxing conditions.

A possible explanation may be related to an implication strategy adopted by the decision-maker. Under a high information load condition, decision-makers will attempt to simplify the task by restructuring it, focusing their attention on regions of data which are thought to be more relevant or excluding irrelevant data. Miller (1956) identified seven mechanisms that the decision-maker evokes: omission (exclusion of information from processing), error (incorrect processing of information), queuing (delaying the processing of information until a lull), filtering (selective processing of information), cutting categories of discrimination (responding with less precision and greater generalization), employing multiple channels (use of parallel sensory channels to process information), and escape (completely ignore the task). Given a complex ranking task, these mechanisms will affect the performance of the judge. This results in an inconsistent application of criteria and ultimately an unreliable ranking. AHP provides an effective means for simplifying a complex ranking task. The effectiveness of AHP has been demonstrated in numerous applications (Gholamnezhad, 1983), (Rao, 1984), (Saaty and Vargas, 1980), (Weis and Rao, 1987), (Wind and Saaty, 1980). AHP begins with a broad statement of the problem, and hierarchically decomposes it into smaller, more manageable and comprehensible subproblems. Pairwise comparisons between the attributes of the problem establish a hierarchy that reflects their (attributes) prioritization. As AHP builds the hierarchy, estimated weights are assigned to the cases and can be interpreted as the coefficients to the objective function (Weis and Rao, 1987).

The major advantage AHP offers over the manual ranking task is the reduction in the number of comparisons. Equation 1 expresses this as the sum of the $n_i - 1$ attributes:

$$\text{number of comparisons} = \sum_{i=1}^{n-1} n_i - 1 \quad (1)$$

where n equals the number of attributes. Thus, in contrast to a manual ranking task during which judges apply their ranking policies, AHP requires judges to state *a priori* their preferences to attributes used to evaluate the cases, and uses an objective function derived from the preferences to determine the rankings.

Methodology

Developing an IS curriculum poses many challenges. The knowledge conveyed to students should reflect its practical application within the business community the curriculum serves. To gain a better insight to current practices, a survey of employers was conducted and incorporated into this study. Because of their diverse operations and their success stemming from the application of different technologies, a cluster analysis was deemed more appropriate to a top- n list of desired skills. Whereas, a top- n list hinges on frequencies (i.e., the number of times an skill appears in a response), cluster analysis recognizes the association among skills that underlie a skill area.

The two components of this study were a manual ranking task, and a computer-assisted preference task. The manual ranking task required participants (judges) to evaluate forty-eight fictitious candidate profiles for their appropriateness and inappropriateness to the judges's organizational operations. The methodology used to analyze the manual rankings requires at least five profiles per attribute (i.e., $5 \times 9 = 45$) to enhance the separation of clusters. Each profile listed nine attributes representing IS skill areas reflected in the course titles, and the candidate's level of proficiency in each area as indicated by a letter grade (Figure 1). Because letter grades were randomly generated, an average grade would not render meaning information (the averages would be approximately the same since the grades were derived from random numbers). Thus, judges were forced to carefully examine each profile. Descriptions of the courses were provided to the judges to help reduce misunderstandings of their focus. Judges ranked (ordered) the candidates from the most to least desirable.

The computer-aided task required judges to indicate their preference for course emphases they deemed appropriate in the context of their organization's IS operations. In contrast to the manual task, judges entered their preferences to pairwise comparisons of the same nine attributes (appearing in the candidate profiles) in a pre-formatted matrix (Figure 2). For example, in the first comparison, judges were asked to specify their preference between advanced COBOL and advanced 4GL programming. As prompted in the lower part of the screen, a positive integer value (between 2 and 9) indicated a preference to advanced COBOL while a negative integer value (between -1 and -9) gave preference to advanced 4GL programming (a 1 meant the two were equally preferred).

Thirty-seven managers and supervisory personnel from nine organizations participated in the survey. The organizations comprise a representative sample of employers who hire many of the graduates from the MIS program of a major west coast university. All judges were involved with the IT and IS functions, and possessed an understanding of their organization's IT needs. The survey was conducted at the employer sites in groups not exceeding seven. This provided the opportunity to clearly explain the purpose and objectives of the survey, and to immediately respond to all questions. Verbal (oral and written) instructions carefully guided the judges through the survey while a demonstration of the software helped reinforce the written instructions. Judges were assigned to perform the tasks in random order.

Results

Regression functions of each judge's manual rankings were first developed to examine the predictive quality of his/her decisions. To create the models, the letter grades were converted to numerical values between 1 (C-) and 8 (A). This allowed

each course to be used as an independent variable and regressed upon the assigned rank of the profile (dependent variable). A preliminary analysis indicated nine could not be modeled linearly, their R-squares falling below .55 ($n = 28$). This suggests that either multiple policies had been applied or criteria were applied inconsistently.

Consistency factors were computed for each judge's set of comparisons (preferences). They are equivalent to R-square in the regression function (i.e., measure of predictive quality). Low consistency factors (less than .1) indicate high predictive quality while high factors (greater than .3) suggest the opposite. An examination of the remaining judges' consistency factors resulted in no further reduction of the sample size. Using the AHP objective functions, a second set of rankings was produced for the remaining judges.

A clustering technique, judgement analysis (JAN), was used to identify and combine regression functions reflecting similar ranking policies. JAN, an agglomerative hierarchical process, is based on a minimal loss of overall predictive efficiency, and seeks to combine functions (policies) that show a minimal drop in predictive quality (R-square). Thus, clusters are based on similar policies. For both data sets, JAN produced four clusters. Tables 1 and 2 list the R-squares and average standard betas, an indication of emphasis, for each cluster.

Discussion

The two tasks differ in complexity as expressed by the number of comparisons a judge would make. During the manual ranking task, a judge can be expected to make 1,128 ($(48^2 - 48)/2$) comparisons with the forty-eight profiles (not including comparisons between individual attributes) as opposed to thirty-six with AHP. The difference suggests that information load will be less of a problem for AHP judges, and the rankings formed through the (AHP) objective function should be subject to fewer errors and less noise.

In addition to possessing higher predictive quality (R-squares greater than .80), the underlying attributes of the AHP-based clusters are more obvious (greater distinction among the standard beta coefficients) (Tables 1 and 2). For example, five attributes form the basis of the first cluster for the manual task. Given the combination of attributes, the emphasis (of the cluster) is unclear and difficult to specify. Its low R-square (.483) suggests a lack of cohesion (binding) among the attributes. Both shortcomings suggest many instances where judges inconsistently applied policies to derive their rankings.

In contrast, the large standard betas of the AHP-derived clusters clearly identify the underlying attributes of each cluster. Based on the judges' preference rankings, the clusters focus on program analysis and design, telecommunications and network implementation, systems analysis, design and implementation, and mainframe application development in COBOL.

In terms of IS curriculum development, the clusters suggest that students need to acquire basic skills and knowledge in these areas. Although all organizations place different emphases on each area, most expressed a desire for students who possess an understand of the fundamentals identified in the clusters. In many cases, organizations prefer to direct their employees toward specialized skills. Given the responses, it would be appropriate to develop a curriculum that embodies these four clusters as a core and includes electives related to them.

Summary and Conclusion

Ranking several cases based upon their attributes poses challenges to judges (i.e., decision-makers). Often, they must judge the case's ability to satisfy an organizational need and its suitability to the organizational environment. As demonstrated by the manual ranking task of this study, rankings can be troubled by the inconsistent application of criteria (ranking policy). AHP provides a computer-aided alternative that decreases the complexity of the task by reducing the number of comparisons (between cases), and directing judges toward identifying *a priori* their attribute preferences. In addition to improved predictive quality, AHP allowed underlying policies to be identified more clearly.

References

References and figures available upon request from first author.

Table 1. Average Standard Betas for Manual Ranking Task

Cluster	<i>n</i>	<i>R</i> ²	x1	x2	x3	x4	x5	x6	x7	x8	x9
1	15	.483	-.16	-.26	-.14	-.18	-.26	-.25	-.30	-.37	-.22
2	8	.763	-.79	-.09	-.22	-.07	-.02	-.01	-.15	-.08	-.04
3	2	.854	-.02	-.01	-.91	-.03	-.04	.01	-.25	.04	-.07
4	3	.792	.02	-.03	.01	.04	.01	-.09	-.09	-.21	-.81

Table 2. Average Standard Betas for AHP

Cluster	<i>n</i>	<i>R</i> ²	x1	x2	x3	x4	x5	x6	x7	x8	x9
1	7	.866	-.12	-.12	-.44	-.33	-.25	-.16	-.58	-.28	-.19
2	7	.821	-.11	-.11	-.19	-.19	-.37	-.18	-.29	-.45	-.55
3	6	.825	-.15	-.19	-.23	-.19	-.35	-.40	-.50	-.52	-.15
4	8	.883	-.65	-.20	-.40	-.27	-.20	-.17	-.33	-.13	-.16

x1 = advance COBOL, x2 = advanced 4GL applications, x3 = data structures/programming logic, x4 = database, x5 = distributed database, x6 = GUI programming, x7 = systems analysis and design, x8 = project management, x9 = telecommunications and networks