Verification of Centrality to Extract Proper Factors in Model Construction Process by Using Creativity Technique

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Abstract. This paper describes the verification of measure to extract factors in a factor model construction process. We have proposed a factor model construction process that uses structural equation modeling and KJ method to construct an objective factor model. KJ method is a creativity technique and a bottom-up approach which members of small group think out, refine, and organize ideas. We apply degree centrality to extract factors from a model constructed by KJ method in this process. There are several different centralities such as closeness and betweenness, which may be superior to degree centrality. Therefore, we verified a method for selecting a centrality by determining the changes in a goodness-of-fit-index and the features of a constructed model by three centralities.

Keywords: Causality analysis, Factor model construction process, SEM, KJ method, Centrality.

1 Introduction

The causality analysis is important in knowledge management, and many enterprises have built a strong relationship with consumers through customer relationship management [1]. As the saying goes, “A satisfied customer is the best advertisement”, so many enterprises perform a causality analysis to determine consumer purchase factors and satisfaction [2]. There are many kinds of statistical methods for causality analysis, such as the factor analysis, regression, and Bayesian network methods [3] [4] [5]. Structural equation modeling (SEM) especially has a beneficial effect on causality analysis because this method can express complex relationships between variables visually and quantitatively by path model [6]. A problem with SEM is that an analyzer can construct a model based on one’s own subjective assumptions, so the objectivity of the constructed model tends to be low. To solve this problem, we propose a factor model construction process that uses KJ method, which is a creativity technique [7]. A creativity technique is a systematic method to creatively solve

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problems by thinking out and organizing ideas. KJ method is a factor model construction method for writing ideas and facts into cards, organizing groups, and connecting groups or cards by links [8]. By using KJ method, we can construct an objective factor model that multiple people can agree on.

In the proposed process, we use degree centrality as a threshold to extract factors because degree centrality means the importance of nodes. However, there are several centralities such as closeness and betweenness, which may be superior to degree centrality [9]. It is possible that we need to use a proper centrality in accordance with the construction of a model. Therefore, in this paper, we perform an experiment, determine the changes in the construction of a model transformed by the differences in centralities, and specify a proper centrality for the proposed process.

The rest of this paper is presented as follows. We describe the outline of our proposed process and the purpose of this paper in Chapter 2. In Chapter 3, the environment and results of the experiment are described, and the results are discussed. Finally, Chapter 4 concludes with a summary of the key points.

2 Proposed Process and Problem

2.1 Factor Model Construction Process

We propose a model construction process that uses KJ method as shown in the following five steps (Figure 1).

1. **Run KJ method:** We perform KJ method by targeting test subjects and obtain the results expressed by cards and their links in order to construct a factor model.
2. **Refine the model by integrating expressions:** We refine the model obtained using KJ method by integrating the expressions of the cards.
3. **Collate cards by data:** We collect the necessary data from the internet and collate cards whose conceptual meanings are approximately equal. We treat collated cards as observed variables and the remaining cards as latent variables.
4. **Extract factors from the results:** We extract factors from the model by setting a threshold for degree centrality.
5. **Analyze by SEM:** We analyze the completed factor model and calculate goodness-of-fit-index (GFI) and the path coefficients, which indicates the strength of the relationships between the variables.

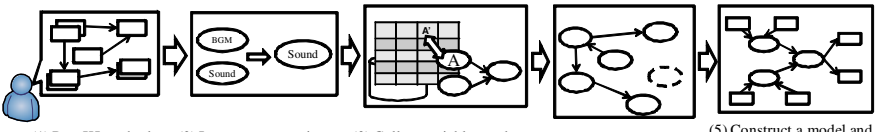

Fig. 1. Procedure of Proposed Process

Table 1. Types and Statistics of Analysis data

Attribute	Type	Max	Min	Average	SD
Graphics	Numeric	10	1	6.803	1.705
Sound	Numeric	10	0	6.742	1.731
Gameplay	Numeric	10	0	6.700	1.897
LastingAppeal	Numeric	10	0	6.455	2.107
Overall	Numeric	10	0.700	6.766	1.795
Price	Integer	153	1	74.61	40.68
Publisher	Factor	-	-	-	-
Month	Factor	-	-	-	-
Genre	Factor	-	-	-	-
Rating	Factor	-	-	-	-
Platform	Factor	-	-	-	-

2.2 Problem and Purpose

For the proposed process, we set a threshold for degree centrality in order to extract important factors in the model. However, it was not clear if degree centrality was appropriate for this process because we had not constructed factor models by using other centralities such as closeness and betweenness [9]. Closeness centrality is expressed by the averages of length between a variable and the others. Betweenness centrality is expressed by the possibility that a variable is contained in the shortest paths between other variables. To specify a proper centrality, we constructed factor models by setting the threshold to three centralities (degree, closeness, and betweenness) and determined the configuration and the changes of the GFI in the constructed model.

3 Experiment

3.1 Experimental Environment

We constructed factor models by gradating the thresholds of three centralities for three models obtained by KJ method. In addition, we specified a proper centrality based on the configuration and the GFI of the constructed models. In the experiment, we set theme to be “the factor for best-selling video games”, generated three groups, and performed KJ method targeting university students. We used data for 5764 video games as analysis data on “IGN Entertainment Games” as analysis data. We also included 11 parameters such as graphics and sound as attributes. Table 1 shows the types and statistics of the analysis data. Note that we treat directional models as non-directional models for the closeness and betweenness centralities because the centralities of most latent variables becomes zero in the directional models.

3.2 Result of Experiment

First, we performed steps 1 to 3 for the three models obtained by KJ method (Figure 2 to 4). In step 4, we applied three centralities and constructed factor models by

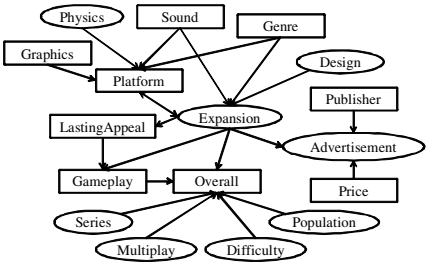

Fig. 2. Basic Configuration of Model 1

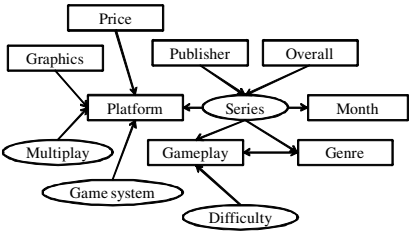

Fig. 3. Basic Configuration of Model 2

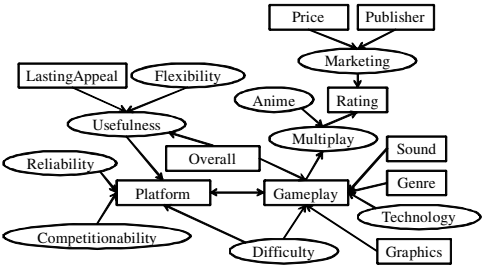

Fig. 4. Basic Configuration of Model 3

gradating the thresholds of the centralities. Table 2 shows the GFI of each model. As can be seen from the table, there were no changes in the GFI among the centralities in this experiment.

For Model 1 and 2, variables located at the edge were preferentially excluded as the threshold became high in all centralities. The reason is that many latent variables located at edge of models and their lengths to other variables are long. For Model 3, variables located at the edge of the models were excluded by priority in the degree and betweenness centralities; however, the latent variables connected to a hub in the model, so the closeness centrality of the variables became high. For example,

Table 2. GFI of Each Centrality

Degree	2	3	4	5	6	7
Model 1	.867	.867	.867	.867	.867	.804
Model 2	.861	.861	.861	.861	.861	.862
Model 3	n/a	n/a	.610	.610	.610	.610
Closeness	3.5	3	2.5	2	1.5	1
Model 1	n/a	n/a	.867	.867	.842	.804
Model 2	.861	.861	.861	.861	.861	.862
Model 3	n/a	n/a	.610	.610	.610	.610
Betweenness	0	0.25	0.5	0.75	1	
Model 1	.868	.868	.842	.842	.804	
Model 2	.861	.861	.861	.861	.861	
Model 3	n/a	.610	.610	.610	.610	

"difficulty" has low degree and betweenness centralities because this variable is located at the edge of the model. However, variables connected to "gameplay" and "platform" had a high degree and were located by the center of the model, so the closeness centrality of the variable became high, and a model having a different configuration was constructed.

From these results, it is clear selecting a proper centrality by contemplating which variable has importance in the model is necessary.

4 Conclusion

In this paper, centralities for extracting factors from factor models were verified. We verified a way to select a centrality by determining the changes in a GFI and the features of a constructed model transformed by three centralities (degree, closeness, and betweenness). In this experiment, there were no differences in GFI for each centrality. However, it is possible that the GFI changes when the configuration of a model is transformed by a centrality. In addition, there are characteristics that exclude latent variables in each centrality. Therefore, it is effective to select a centrality by contemplating which variable has importance in the model. For instance, if we focus on the vulnerability of models, it is effective to apply the betweenness centrality, and, if we emphasize the number of degrees, the degree centrality is a proper centrality.

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