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Developing a Case-based Reasoning System of Leisure Constraints

[1]Fei-Rung Chiu, [2]Cheng-Yi Wang, [3]Yu-Cheng Huang and [3]Yan-Kwang Chen
[1]Department of Tourism and Recreation Management, Overseas Chinese University,
100 Chiao Kwang Road, Taichung, Taiwan, Republic of China
[2]Graduate Institute of Technology and Innovation Management, National Chung Hsing University,
250 Kuo Kuang Road, Taichung, Taiwan, Republic of China
[3]Department of Logistics Engineering and Management, National Taichung Institute of Technology,
129 Sanmin Road, Sec. 3, Taichung, Taiwan, Republic of China

Abstract: This study applies the Case-Based Reasoning (CBR) technique to develop a case repository-based leisure constraints inference system. This system is expected to predict the type of leisure constraints that visitors encounter and help leisure service providers in negotiation of the constraints and strategic marketing. Empirical findings suggest that the hit rate of the proposed system for visitors' leisure constraints reaches 54.83%.

Key words: Leisure constraints, artificial intelligence, case-based reasoning, cluster analysis, market segmentation, customer classification

INTRODUCTION

Leisure constraints are various limitations and difficulties that affect people's participation in and satisfaction with leisure activities (Chubb and Chubb, 1981; Tsai and Coleman, 1999). Jackson (1988) found that leisure constraints are main factors confining people's participation in leisure activities. Early studies of leisure constraints have roughly classified leisure constraints into internal constraints and external constraints. Internal constraints refer to constraints caused by individual status, capabilities, knowledge, gender, age and interpersonal relations, while external constraints are caused by environmental factors, transportation, economic status, social and demographic structure, time and money (Boothby *et al*., 1981; Chubb and Chubb, 1981; Franken and Van Raaij, 1981). Jackson and Dunn (1988) pointed out that one's attitude toward and behavior of participation in leisure activities are affected by individual values and perceptions of environmental changes. As a result, people may refuse or cease participation in leisure activities due to internal constraints or external constraints.

With the change of the leisure environment, this early taxonomy of leisure constraints may not sufficiently describe the constraints to an individual's participation in leisure activities. According to Crawford and Godbey (1987), internal constraints should include intrapersonal and interpersonal factors. They identified three types of leisure constraints, including intrapersonal constraints, interpersonal constraints and structural constraints (Fig. 1). Intrapersonal constraints refer to leisure preferences derived from personal beliefs, habits and experiences. Personality, attitude, emotion, religion, subjective values and past experience of leisure activities can all become intrapersonal constraints. Interpersonal constraints arise when co-participation of family members, peers or friends in certain leisure activities is required. For instance, one may have low intention to participate in leisure activities without companion. Structural constraints are most frequently seen in leisure activities. They are caused by external or irresistible conditions, such as seasonal and climatic factors, leisure resources, equipment, time and money (Crawford and Godbey, 1987; Jackson, 2005; Kim and Trail, 2010; Raymore *et al*., 1993; Raymore, 2002; Shaw and Henderson, 2005). Barbara *et al*. (1999) extended the research by Crawford and Godbey (1987) to discover that intrapersonal constraints are insignificant factors of non-participation; interpersonal and structural constraints are more influential than intrapersonal constraints.

Crawford and Godbey (1987) mentioned that leisure constraints may not necessarily cause non-participation in leisure activities. One's participation in leisure activities depends on the outcome of his or her negotiation with leisure constraints. Participation in leisure activities

Corresponding Author: Yan-Kwang Chen, Department of Logistics Engineering and Management,
National Taichung Institute of Technology, 129 Sanmin Road, Sec. 3, Taichung, Taiwan, Republic of China

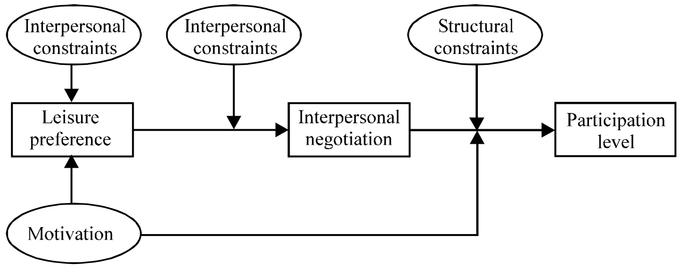

Fig. 1: The hierarchical model of leisure constraints (Jackson *et al*., 1993)

occurs only when one has overcome intrapersonal, interpersonal or structural constraints to have stronger desire for participation in leisure activities (Crawford and Godbey, 1987; Crawford *et al*., 1991; Jackson and Searle, 1985; Goodale and Witt, 1989). Besides, Jackson *et al*. (1993) discovered that people usually actively negotiate constraints to participate in activities rather than passively refuse participation in them and chances of their participation in leisure activities increase when they have successfully overcome leisure constraints. For example, one may rearrange or adjust his or her plan, priorities of expenses and other aspects of life to make participation in certain leisure activities possible. Therefore, Jackson *et al*. (1993) proposed that strategies for negotiating leisure constraints, which may vary from one person to another, can be basically divided into behavioral and cognitive strategies. Behavioral strategies are to resolve constraints through change of attitude, preference or behavior and reduction of psychological inadaptability. They are intended to reduce obstruction by making substantive changes in one's leisure behavior. Cognitive strategies are to solve constraining problems through negotiation. For instance, if the incentives for participation can be enhanced, costs of participation reduced or the rewards for participation improved, people will perceive less obstruction and have less incongruent cognition of leisure activities.

Generally, people have different perceptions of various leisure constraints, so they need to adopt strategies suitable for themselves to negotiate the constraints (Jackson *et al*., 1993). People feel motivated to participate in leisure activities and attempt to overcome other secondary constraints only when their perceptions of obstacles and desires for participation reach a balanced state. They will not engage in leisure activities until they have overcome leisure constraints through use of negotiation strategies (Hubbard and Mannell, 2001; Iwasaki and Schneider, 2003; Jackson *et al*., 1993; Paker, 2007; Samdahl and Jekubovich, 1997; Schneider and Stanis, 2007; White, 2008). To overcome leisure constraints, behavioral and cognitive strategies will be used, either alone or together. If we can find out the type of leisure constraints that visitors encounter, we can use appropriate negotiation strategies to help them overcome the constraints and increase their motivation and intention of leisure participation. In addition, negotiation strategies for different types of constraints also differ. A number of feasible negotiation strategies have been proposed. For instance, for intrapersonal constraints such as lack of vigor, shyness, feeling embarrassed when changing clothes before companions or easily obsessed with leisure activities, the following strategies can be used: (1) encourage putting away sense of dignity and dedicated participation, (2) encourage seeking accompanying of close friends, (3) limit the participation time (Alexandris *et al*., 2003; Hubbard and Mannell, 2001; Son *et al*., 2008). For interpersonal constraints such as companions being unavailable at the leisure time, feeling bored with the activity or having to travel a long distance for the activity, the following strategies can be used: (1) encourage seeking new friends to participate in the activity, (2) encourage seeking friends with interest in similar fields, (3) encourage inviting friends to participate in the activity (Hubbard and Mannell, 2001; Mannell and Loucks-Atkinson, 2005; Son *et al*., 2008). For structural constraints such as absence of proper clothes, unavailability of time, worries over weather conditions, being busy with numerous trivial affairs and high cost of participation, the following strategies can be used: (1) encourage immediate preparation for necessary equipment or clothes, (2) suggest shortening the time allocated for other appointments, (3) encourage participation if all conditions permit, (4) suggest making a list of personal tasks and (5) promote the activity or offer gifts (Alexandris *et al*., 2003; Hubbard and Mannell, 2001; Jackson and Rucks, 1995; Mannell and Loucks-Atkinson, 2005; Son *et al*., 2008; White, 2008).

Many researchers have explored factors causing leisure constraints, including demographic variables (e.g., age, occupation, gender, social status and income) or other constraints (e.g., season, distance, traffic and safety) to clarify how to overcome leisure constraints and enhance people's intention for leisure participation (Boothby *et al*., 1981; Hudson and Gilbert, 2000; Jun *et al*., 2009; Kattiyapornpong and Miller, 2009; Mowen *et al*., 2005; Nicolau and Mas, 2005; Romsa and Blenman, 1989; Teaff and Turpin, 1996). It is generally believed among them that demographic variables affect people's leisure participation, both directly and indirectly and are key factors of leisure constraints.

In recent years, Artificial Intelligence (AI) has been extensively applied to solution of problems in numerous fields. It can simulate human behavior and thinking models to yield inferences without a long knowledge acquisition and complicated computation process. Case-Based Reasoning (CBR) is one of the techniques developed by Schank and Abelson (1977) on the basis of artificial intelligence. It assumes that similar problems have similar solutions and problems encountered occur frequently, so new problems can be solved using solutions to past problems (Chen *et al*., 2010; Schank and Abelson, 1977; Tseng *et al*., 2005).

Based on the CBR technique, we will first build a case-based reasoning system of leisure constraints. Through this system's effective prediction of visitors' leisure constraints, we expect to help leisure service providers in negotiation of the constraints and achieve strategic marketing. Later, we will use a historic preservation area in Taiwan as an example to validate the feasibility and performance of the system.

THE CASE-BASED REASONING SYSTEM OF LEISURE CONSTRAINTS

CBR is one of the techniques of artificial intelligence. Like human reasoning, it searches for solutions to current problems from past cases or experiences. It can solve non-structured and complicated problems and has the instant update capability (Ahn *et al*., 2007; Chen *et al*., 2010; Kolodner, 1993; Shin and Han, 1999).

Based on the theory of CBR, we will construct a cased-based reasoning system of leisure constraints in four steps (Fig. 2). Below is a brief explanation of the four steps.

Step 1: Case representation: Select cases of leisure constraints and use factors of leisure constraints, including demographic variables (e.g., gender, age, education, occupation, monthly income and marital status), intrapersonal constraints, interpersonal constraints and structural constraints as features or attributes to sufficiently represent the cases.

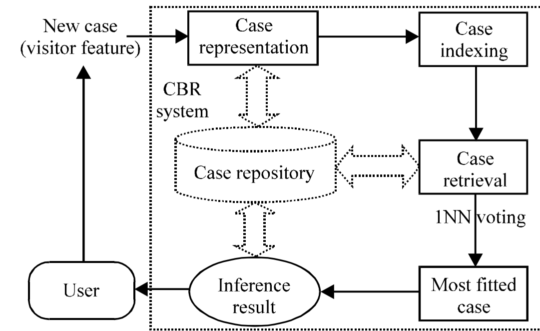

Fig. 2: The structure of the case-based reasoning system of leisure constraints

Step 2: Case indexing: Classify and index the cases by features or attributes to facilitate fast search and retrieval of cases (Chen *et al*., 2010).

Step 3: Case retrieval: With all the cases indexed, the CBR system can compare the new case with all the old ones stored in the case repository and retrieve the most similar case. In this study, our case repository consists of three case sets, including reference cases, test cases and hold-out cases. Reference cases are used for inference in CBR, while test cases or hold-out cases are viewed as new cases to be input in the CBR system.

When, a new test case is input in the system, the system will represent the leisure constraints encountered and begin the reasoning process. Based on the case index, the system computes the distance between the test case and each reference case to find the closest one, from which the solution to the test case can be derived.

$$\text{Distance}\,(R_i, T_j) = \sqrt{\sum_{k=1}^{n} \left(R_{ik} - T_{jk}\right)^2} \qquad (1)$$

where, R_i denotes reference case i; T_j denotes test case j; R_{ik} denotes the kth feature of reference case i; T_{jk} denotes the kth feature of test case j and n is the number of features of the case.

Step 4: Case adaptation: Store the latest and suitable cases in the case repository to achieve self-learning of the system.

CASE STUDY

In this study, we used visitors to Lukang Historic Preservation Area as subjects to establish a case-based system of leisure constraints. Because a huge amount of data was required for CBR, we collected real cases of leisure constraints through a questionnaire survey and then applied simulation techniques to generate simulated cases to build a case repository for our CBR system.

Data collection: The questionnaire was administered online (http://www.my3q.com/). The issue was entitled Taiwan experience of historic preservation area travel survey and the investigation of the period was 31 days. Lukang historic preservation area is one of the popular tourist locations in Taiwan and also a cradle of Taiwan's folk culture. Visitors to this tourist location are diverse, including young and old, alone or with a group. They are very suitable for being the subjects for our research of leisure constraints. Through our system's analysis of potential visitors, we expect to offer the government and tourism service providers some appropriate promotional strategies.

Previous literature suggested that basic demographic variables are key factors affecting visitors' leisure participation. In this study, we used gender, age, education, occupation, average monthly income and marital status as features or attributes for case representation. Among these demographic variables, gender, occupation, marital status and intention for participating in leisure activities in this area were measured using nominal scales; education was measured using an ordinal scale; age and monthly income were measured using continuous scales (Table 1). To facilitate subsequent analysis, we combined intrapersonal constraints and interpersonal constraints as internal constraints and defined structural constraints as external constraints. For some visitors, internal constraints and external constraints might co-exist. Hence, they were classified by whichever constraints caused the highest obstruction. The obstruction of all the above constraints was measured by ordinal scales. Because the scale and range of case features varied from one case to another, we standardized each case feature to make it fall between 0 and 1 in the measurement of similarity between cases.

Case simulation: We obtained a total of 80 real cases. Based on the pattern of their features, we further simulated 600 cases through the following process:

Step 1: Calculate the mean scores of internal constraints and external constraints in each real case

Each case contained features of intrapersonal constraints, interpersonal constraints and structural constraints. Based on the features of each type of constraints, we calculated the mean score of each type of constraints in each case.

Table 1: The dimensions and scales used in the questionnaire

Factor	Feature	Scale
Demographic variables	Gender	Nominal
	Age	Continuous (Years)
	Education	Ordinal
	Occupation	Nominal
	Average monthly income	Continuous (NTD)
	Marital status	Nominal
	Intention for leisure participation	Nominal
Intrapersonal constraints	Lack of available time	Ordinal
	Personality	Ordinal
	Lack of sufficient money	Ordinal
	Lack of good physical conditions	Ordinal
	Lack of transportation vehicles	Ordinal
Interpersonal constraints	Public opinion (positive)	Ordinal
	Public opinion (negative)	Ordinal
	Lack of companions (active)	Ordinal
	Lack of companions (passive)	Ordinal
	Lack of companions with similar interest	Ordinal
Structural constraints	Seasonal and climatic impact	Ordinal
	Attraction of the scenic spot	Ordinal
	Accessibility	Ordinal
	Food service	Ordinal
	Crowdedness	Ordinal
	Inconvenience of public facilities at the scenic spot	Ordinal
	Environmental impact	Ordinal
	Tour guidance	Ordinal

Table 2: Statistics of leisure constraints in collected real cases

Type of leisure constraint	No. of cases (ratio)	Note
Internal constraints	26 (32.50%)	19 with intrapersonal constraints 7 with interpersonal constraints
External constraints	45 (56.25%)	45 with structural constraints
No constraint	9 (11.25%)	9 with no constraint

Step 2: Classify cases by the main type of leisure constraints

We classify cases by the type of constraints with the highest mean score. Cases with the highest mean score of constraints below 3 points were deemed as cases with no leisure constraints. The results are as shown in Table 2.

Step 3: Simulate cases according to the ratios of constraints (i.e., pattern of features) among real cases

Based on the ratio of each type of constraints among real cases, we simulated a total of 600 cases, including 195 cases with internal constraints (=600×32.50%), 338 cases with external constraints (=600×56.25%) and 67 cases with no constraint (=600×11.25%). We simulated the case features strictly according to the distribution of features in real cases.

Take external constraints as an example. A total of 45 real cases, including 21 male cases and 24 female cases, were classified into this category. In case simulation, male cases were randomly generated at probability of 21/45

Table 3: Data conversion table

Case feature	Description	Value
Gender	Male	1
	Female	2
Age	0 ~ 27	1
	28 ~ 46 or above	2
Education	Under (and including) senior or vocational high school	1
	College or graduate school or above	2
Occupation	Student, seeking employment or unemployed	1
	Public servant, employee in the service industry or nine-to-fiver	2
Monthly income	Under $9,999	1
	10,000 ~ 40,000 or above	2
Marital status	Married	1
	Single	2

Table 4: Data structure of the case repository

Case	Gender	Age	Education	Occupation	Average monthly income	Marital status	Type of constraints
Case001	1	2	1	1	2	1	2
Case002	2	1	2	2	2	2	3
Case003	1	2	1	1	1	2	1
…	…	…	…	…	…	…	…
Case600	1	2	1	1	2	2	3

while female cases at 24/45. To reduce complication of simulation, we binarized all the feature values, as shown in Table 3 and 4.

System test: After data collection, we divided the 600 cases into three proportions, 60, 20 and 20% (Chen *et al*., 2010) at random. 360 cases (=600×60%) were classified as reference cases, 120 cases (=600×20%) as test cases and 120 cases (=600×20%) as hold-out cases.

We built the case repository using microsoft office excel 2003 and applied the programming functions of VBA (visual basic for application) to develop the system.

For each test case j, we used Eq. 1 to compute the distance between this case and other cases in the repository (R_i, i = 1, 2,..., 360) and select the closest case to infer the type of leisure constraints that the test case belongs to (expect output, EO_j).

The hit rate was estimated using the following equation:

$$\text{HitRate} = \sum_{j=1}^{N} \text{hit}_j / N \tag{2}$$

In the above equation, N denotes the number of test cases (in this study, N = 120); hit_j denotes the fit between the inferred result (expect output, EO_j) and the actual result (actual output, AO_j); if $EO_j = AO_j$, $hit_j = 1$; otherwise; $hit_j = 0$.

Using the reference cases for reasoning, we obtained a hit rate of 54.67% for test cases and 51.17% for hold-out cases.

Table 5: Denotations for classification accuracy

Classification results	Internal constraints	External constraints	No constraint	Total
Internal constraints	n_{11}	n_{21}	n_{31}	N_1
External constraints	n_{12}	n_{22}	n_{32}	N_2
No constraint	n_{13}	n_{23}	n_{33}	N_3
Total	n_1	n_2	n_3	N

Performance evaluation: To validate the leisure constraints classification performance of the proposed system, we analyzed the classification results by Total Accuracy (TA) and Individual Accuracy (IA). We assumed that the test cases (or hold-out cases) contain n_1 cases with internal constraints, n_2 cases with external constraints and n_3 with no constraint and our system classifies N_1 cases into the category of internal constraints, N_2 into external constraints and N_3 into no constraint (Table 5). TA denotes the system's classification accuracy for all types of constraints:

$$\text{Total accuracy} = \frac{n_{11} + n_{22} + n_{33}}{N} \tag{3}$$

IA denotes the system's classification accuracy for each individual type of constraints:

$$\text{Individual accuracy (internal)} = \frac{n_{11}}{n_1} \tag{4}$$

$$\text{Individual accuracy (external)} = \frac{n_{22}}{n_2} \tag{5}$$

$$\text{Individual accuracy (none)} = \frac{n_{33}}{n_3} \tag{6}$$

To understand if our system performance would be affected if different case sets were used, we generated 10 sets of reference cases, test cases and hold-out cases at random according to their original proportions (60, 20 and 20%, respectively). In the 10 tests, the mean TA for test cases was 55.8% and the mean TA for hold-out cases was 53.92%.

Further, we analyzed the IA for each type of cases (i.e., cases with internal constraints, cases with external constraints and cases with no constraint). In terms of test cases, the IAs for the three types of cases were 54.61, 55.74 and 53.08%, respectively. In terms of hold-out cases, the IAs were 53.59, 54.26 and 53.08%. These figures revealed that although the proportions of the three types of constraints were different in the two case sets, the classification accuracy of the system was not significantly affected. Therefore, our system was developed with sufficient robustness.

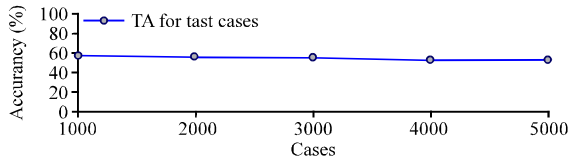

Fig. 3: TA for test cases under different amounts of cases

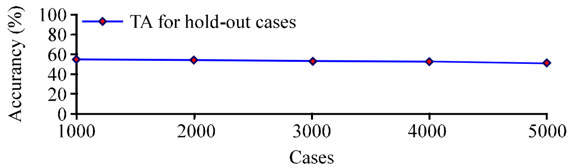

Fig. 4: TA for hold-out cases under different amounts of cases

In practical applications, this system may need to process a huge number of cases. Therefore, we tested whether its accuracy would be affected if the data to be processed were drastically increased. Starting from 1000 cases, we added 1000 more simulated in each test until the total number of simulated cases reached 5000. The results of five test conditions are shown in Fig. 3 and 4. The mean TAs for test cases and hold-out cases in the five tests were 54.83 and 53.67%. From these Fig. 3 and 4, we could infer that 600 cases were already enough for CBR.

Results: In our empirical test of the CBR system using simulated cases, the mean TAs for test cases and hold-out cases reached 54.83 and 53.67%, respectively. These figures suggested that demographic variables had sufficient predicting power for the type of leisure constraints. In other words, our system could effectively predict visitors' perceptions of constraints in a leisure activity and leisure providers could use the system to analyze the possible constraints that visitors are most likely to encounter. Our system could help authorities of Lukang Historic Preservation Area avoid failure in marketing leisure and tourism activities. It could offer considerable assistance to improvement of tour revenues or other promotional efforts.

DISCUSSIONS AND CONCLUSIONS

In this study, we developed a case-based reasoning system of leisure constraints to infer the type of leisure constraints that visitors may encounter and provide service providers directions to set up customized solutions. For instance, for visitors with internal constraints, they could adopt behavioral negotiation strategies to encourage them to seek companions or use marketing strategies to change their preference for or attitude toward leisure. For visitors with external constraints, they were advised to adopt cognitive negotiation strategies to increase visitors' leisure intention by offering discounts or gifts (Hubbard and Mannell, 2001; Jackson *et al*., 1993; Schneider and Stanis, 2007; White, 2008). Of course, they could also adopt the above two types of strategies at the same time to achieve synergy.

The proposed CBR system was designed to use all cases in the repository for inference, so it had to compare all the old cases with the new case (new visitor's features). In practical application, its performance may be dragged down if the amount of visitors to be processed is large. Therefore, future researchers are suggested to apply instance selection to optimize the system's case indexing performance (Ahn *et al*., 2010). Besides, we generated the case repository through case simulation. To simplify the computation process, we binarized feature values (either 1 or 2). All these could affect the system's inference accuracy. Hence, future researchers are suggested to use multi-point scales to measure case features or attributes to increase the system's accuracy in case retrieval (Chen *et al*., 2010). Moreover, feature selection is also an important factor affecting CBR accuracy. Future researchers could select more suitable case features to further improve the system's inference accuracy (Lin *et al*., 2008).

Overall, the CBR system of leisure constraints proposed in this study was focused on prediction of the type of leisure constraints that visitors might encounter. In future development of this system for practical applications, if negotiation strategies for each type of constraints could be included to increase the system's decision support capability, this system could be more valuable and contributive to the practice.

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