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Editors

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Intelligent Decision Technologies

Proceedings of the 4th International Conference on Intelligent Decision Technologies (IDT´2012) - Volume 2

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Preface

The Intelligent Decision Technologies (IDT) International Conference encourages an interchange of research on intelligent systems and intelligent technologies that enhance or improve decision making. The conference is organized by KES International, a research community consisting of several thousand research scientists. The focus of IDT is interdisciplinary and includes research on all aspects of intelligent decision technologies, from fundamental development to real applications.

Advances in Artificial Intelligence (AI) and computing environments that can deliver intelligent technologies effectively have enabled an explosion in intelligent applications. IDT have the potential to expand their support of decision making in such areas as finance, accounting, marketing, healthcare, medical and diagnostic systems, military decisions, production and operation, networks, traffic management, crisis response, human-machine interfaces, financial and stock market monitoring and prediction, and robotics. Intelligent decision systems implement advances in intelligent agents, fuzzy logic, multi-agent systems, artificial neural networks, and genetic algorithms, among others. Emerging areas of active research include virtual decision environments, social networking, 3D human-machine interfaces, cognitive interfaces, collaborative systems, intelligent web mining, e-commerce, e-learning, e-business, bioinformatics, evolvable systems, virtual humans, and designer drugs.

In this volume we publish research from the Fourth KES International Symposium on Intelligent Decision Technologies (KES IDT'12), hosted and organized by researchers in Japan. The conference was held in Gifu City located in the center of Japan. Gifu City is known for its traditions and rich history, including its 1300-year-old tradition of cormorant fishing on the Nagara River and Gifu Castle. This book contains chapters based on papers selected from a large number of submissions for consideration for the symposium from the international community. Each paper was double-blind, peer-reviewed by at least two independent referees. The best papers were accepted based on recommendations of the reviewers and after required revisions had been undertaken by the authors. The final publication represents the current leading thought in intelligent decision technologies.

We wish to express our sincere gratitude to the plenary speakers, invited session chairs, delegates from all over the world, authors and reviewers for their outstanding contributions. We express our sincere thanks to the Japanese organizers and Gifu City for their sponsorship and support of the symposium. We thank the International Programme Committee for their support and assistance. We would like to thank Peter Cushion of KES International for his help with organizational issues. Also our appreciation is extended to their contribution provided by the KES International Secretariat Team. We thank the editorial team of Springer-Verlag for their support in production of this volume. We sincerely thank the Local Organizing Committee, especially Professors K. Asakura in Daido University and T. Kojiri in Kansai University for their editing conference record and program, and their collaborators for their invaluable contributions.

We hope and believe that this volume will contribute to ideas for novel research and advancement in intelligent decision technologies for researchers, practitioners, professors and research students who are interested in knowledge-based and intelligent engineering systems. At the end we will express thanks for Dr. Jerzy Michnik, University of Economics in Katowice, Poland, for his help on Latex.

Gifu, Japan
May 22–25, 2012

Junzo Watada
Toyohide Watanabe
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Editors

Professor Junzo Watada received his B.Sc. and M.Sc. degrees in electrical engineering from Osaka City University, and Dr. of Eng. Degree from Osaka Prefecture University, Japan. He is currently a Professor of Knowledge Engineering, Soft Computing and Management Engineering at the Graduate School of Information, Production & Systems, Waseda University, after a professor of Human Informatics and Knowledge Engineering at the Osaka Institute of Technology, Japan and was with Ryukoku University, Kyoto for about 10 years each. Before moving to Academia, he was with Fujitsu Co. Ltd. for about 10 years. His research interests includes decision making tehnologies and management of technology. Dr. Watada is currently the President of International Society of Management Engineers. He was a co-chair of KES-IDT2011 at Pireus, Greek and plays an active role in editing International Journal of Intelligent Decision Technology (KES official journal) as a co-editor-in-chief.

Toyohide Watanabe has received B.S., M.E. and Dr.Eng. from Kyoto University, in 1972, 1974 and 1985, respectively. Since 1975, he has worked in Kyoto University and Nagoya University: first as a research associate in Data Processing Center, Kyoto University, from 1975 to 1987; second as an associate professor Faculty of Engineering, Nagoya University, from 1987 to 1994; third as a full professor in the same faculty, from 1994 to 1997; fourth as a professor in Graduate School of Engineering, Nagoya University

from 1997 to 2003; and finally as a professor in Department of Systems and Social Informatics, Graduate School of Information Science, Nagoya University, since 2003. Additionally, from 2004 to 2008 he was the head director in Information Technology Center, Nagoya University. The current topics of his research interests are: Intelligent Tutoring System, Computer-supported collaborative learning, Knowledge management, Intelligent activity-support, etc. He is a member of ACM, IEEE-CS, AAAI, AACE, KES International, IEICE of Japan, IPS of Japan, IEE of Japan, Japan of SAI, Japan of SSST, JSiSE, etc. Also, currently he is an Editor-in-Chief of the International Journal of Knowledge and Web Intelligence. Moreover, he is a fellow on IEICE of Japan since 2004.

Dr. Gloria Phillips-Wren is Professor and Chair of Information Systems and Operations Management at Loyola University Maryland, and Academic Director of Executive Programs. She is co-founder and co-editor-in-chief of Intelligent Decision Technologies International Journal (IDT), Vice Chair and Chair-elect of SIGDSS under the auspices of the Association for Information Systems (AIS), Secretary of IFIP WG8.3 DSS, and leader of the focus group in Intelligent Decision Technologies (IDT) for KES International. She is a co-organizer of the IDT Conference Series under the auspices of KES International. She received a PhD from the University of Maryland Baltimore County and holds MS and MBA degrees. Her research interests and publications are in intelligent decision support systems, intelligent agents, decision making, analytics, business intelligence, data mining, and emerging technologies such as social media. She has published in the area of decision making and support in academic journals including the European Journal of Operational Research, Omega, Expert Systems with Applications, and the Journal of Network and Computer Applications. Her most recent book (co-edited) was published in 2011 and is entitled Intelligent Decision Technologies.

Robert Howlett is the Executive Chair and Chief Executive of the KES (Knowledge-Based and Intelligent Engineering Systems) International. KES is an associaton dedicated to knowledge exchange and the dissemination of research results in the areas of intelligent systems, sustainability in energy and buildings and innovation through knowledge transfer. He is a Director of the Institute of Knowledge Transfer, the body for knowledge professionals and researchers working in innovation, knowledge transfer and enterprise. He holds a Visiting Professorship in Enterprise at Bournemouth

University. He holds a PhD in Intelligent Systems from the University of Brighton, an MPhil from Sussex University and a BSc(Hons) from Portsmouth Polytechnic. He is a Chartered Engineer and a Chartered Information Technology Practitioner. He was at the University of Brighton for over 20 years where he headed a research group in intelligent systems and the was Director of the Knowledge Transfer Partnerships (KTP) Centre. For a number of years he chaired the KTP national Forum, representing KTP centres from all universities in the country, which he formed. He has been involved with innovation knowledge transfer, as a practitioner, facilitator and manager, for over 15 years. He has personally supervised many knowledge transfer projects and written and mentored many more.

Professor Lakhmi Jain is a Director/Founder of the Knowledge-Based Intelligent Engineering Systems Centre. His interests focus on the novel techniques such as knowledge-based intelligent machines, virtual systems, intelligent agents, and the application of these techniques in areas such as engineering, science, aviation, healthcare, defence and so on.

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Part I

Applications of Intelligent Decision Technology

Evaluating Top Services-Prepackaged Software Firms in Standard and Poor's 500 Index by Using a Multiple Objective Programming Based Data Envelopment Analysis

Chi-Yo Huang, Po-Yen Wang, and Gwo-Hshiung Tzeng

Abstract. Services-prepackaged software firms are a field of Information technology (IT). IT is defined as the obtainment, procedure, storage and propagation of sounding, drawing, and textual information by combining microelectronics-based computing and telecommunications. Nowadays, IT has penetrated in daily life of human beings and become one part of the whole society. The importance of IT has become momentous. Therefore, to understand the performance of efficiency and productivity of the IT firms is critical for managers as well as for personal investors. Until now, there are very few researches tried to analyze final performance of the services-prepackaged software firms in IT sector. As a result, this research intends to use traditional Data Envelopment Analysis (DEA) CCR or BCC models to evaluate the performance of the services-prepackaged software firms. However, the traditional DEA models are not fair models from the aspect of improper weight derivations. Thus, this paper intends to analyze the efficiency of the services-prepackaged software firms by using multiple objective programming (MOP) based DEA. The Decision Making Units (DMUs) on this research are chosen from the services-prepackaged software firms in S&P 500 based on publicly available financial reports of the fiscal year 2010. In a MOP based DEA approach, DMUs will be evaluated based on an equal standard and the results will be evaluated more fairly. In the empirical study, the MOP based DEA demonstrated that Autodesk Inc.,

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BMC Software, and Citrix Systems should be the services-prepackaged software firms worthwhile to be invested. In the future, performance evaluation results can be served as foundations for investment strategies definition.

Keywords: Information Technology (IT), Standard and Poor's 500 index, Performance Evaluation, Data Envelopment Analysis (DEA), Multiple Objective Programming (MOP).

1 Introduction

In the twenty-first century, information technology (IT) has penetrated in daily life of human beings and become one part of the whole society. IT was first appeared by Harvard Business Review in 1958 since this new technology does not have a unique established name. IT depends on its reshaping by the basics of business and customer service, operations, product and marketing strategies, and distribution entirely (Keen, 1991). Also, IT plays an important role in knowledge-based economy around the world nowadays. The appearance of information technologies, especially in internet fields, has changed everything in whole world's business; it has, especially, affected the developing, marketing, and distributing procedures of products. Thus, obtaining a competitive advantage over competitors is the required precondition to survive in rival global market nowadays. The field of IT industry is broad. By using Standard Industrial Classification (SIC) code which is a United States government system for classifying industries by a four-digit code to choose IT firms, it shows that every company have different major products in its field. The author selects the services-prepackaged software firms to evaluate the performance. The reasons for selecting this classification of IT firms are mentioned in the following. Jorgenson (2001) also indicated that the investment in software is growing fast and much more critical than computer hardware investment. Besides, Parker & Grimm (2000) described the new estimation of investment in software.

Top managers in most organizations always want to know whether investment into IT has any linkage to the overall performance of the firm. There have been some researches concerning the performance of IT by using different methods. Therefore, performance evaluation plays an essential role in management process. It not only provides critical information for decision-making, but also gives a foreseeable advantage for following operations (Phillips, 1999). Hence, how to use performance evaluation to measure organizational performance in a multidimensional construct is important to determine a whole management procedure (Lewin and Minton, 1986).The data envelopment analysis (DEA) is a flexible tool and can be molded with other analytical methods. DEA is a mathematical programming approach to evaluate the relative efficiency of peer units of multiple performance measures (Charnes et al., 1978; Cooper et al., 2004).Thus, DEA methods have become popular tools, which were widely adopted on national, industrial as well as firm level performance evaluations.

Although DEA approaches were widely adopted on performance evaluations of nations, industries as well as firms, such performance evaluation results were derived based on different bases of comparisons of DMUs. Nevertheless, traditional

DEA approaches which were usually leveraged on firms' performances are based on the unfair weights' problems as mentioned by Fare and Hunsaker (1986). Apparently, to resolve the disadvantages being introduced by traditional DEA approaches, an appropriate measure of the IT by a suitable method is required. To resolve the above mentioned disadvantages being introduced by traditional DEA approaches, this research aims to introduce a Multiple Objectives Programming (MOP) based DEA method being developed by Prof. Gwo-Hshiung Tzeng (Chiang and Tzeng, 200a, 2000b) to evaluate the performance of the top IT firms in S&P 500. In the novel MOP based DEA approach, DMUs will be evaluated based on an equal standard (Chiang and Tzeng, 2000a, 2000b; Liu, Lee and Tzeng, 2004). By this approach, the efficiency rating of each DMU can be evaluated more fairly than the traditional CCR approach being proposed by Charnes et al. (1978).

In this research, the definition of the background, motivations and problem findings of this whole research will be first introduced. Secondly, the related literature according to performance evaluation and efficiency and productivity will be summarized by literature review. Then, the top services-prepackaged software firms in S&P 500 will serve as DMUs. Following, selecting the same inputs and outputs to evaluate the performance by traditional CCR model and then by the MOP based on DEA model. Finally, the differences between two different models and managerial implications will be compared and discussed.

The remainder of this paper is organized as follows. The related literature regarding to performance evaluation and efficiency and productivity will be reviewed in Section 2. The analytic framework based on CCR, BCC, and MOP based DEA methods will be introduced in Section 3. Then, in Section 4, the results of evaluating by CCR and MOP based DEA will be shown as an empirical study. Managerial implications as well as discussion will be presented in Section 5. Finally, the whole article will be concluded in Section 6.

2 Literature Review

In this Section, the author will review some literature with regard to the productivity and efficiency as well as performance evaluation. In the following Sub-sections, the definitions and literature of productivity and efficiency will be reviewed first. Then, the performance evaluation will be reviewed in the following part of this Section.

2.1 Productivity and Efficiency

The definition of efficiency is that the minimum resource level which is abstractly needed to conduct the desired operations in a given system when contrasted to the actual resource has been used (Sumanth, 1994; Tangen, 2005). Based on Coelli et al. (2005), the normal measurement of efficiency is used to measure a firm as the ratio of the outputs, and measure produces as the ration of the inputs. The existence of multiple inputs and outputs in regard to distinct resources, actions and environmental factors (Emrouznejad, 1995) cause the formula is usually insuffi-

cient (Coelli et al., 2005). The term "efficiency" concerns about the relationship between the amounts of required input to the amount of produced output.

Productivity is one of our most basic and intuitive measures of performance. At the firm level, productivity is a component of profit growth along with price changes, and at the aggregate level. Productivity is a fundamental part of economic growth and welfare. To determine the productivity of any organization, it is required to have a tool to measure it. Over the time period, measuring productivity would be helpful for the organization to compare the performance towards the industry of similar firms or similar service providers, and to compare the productivity of a certain department (Helms, 2006).

2.2 Performance Evaluation

Performance evaluation is an important part of the procedure of management. Performance evaluation not only provides required information for decision-making, but also gives a rival advantage for following operations (Phillips, 1999). As a result, it is critical to decide how to measure performance more organized in a multidimensional construct (Lewin and Minton, 1986). Among the methods of evaluating organizational performance, the technique of data envelopment analysis (DEA) proposed by Charnes et al. (1978) will be the most representative method of performance evaluation.

The performance evaluation based on DEA method has been widely used in a variety of fields, including airlines, banking, insurance, life insurance companies, telecommunications, transportation companies, textile companies, hotel industry, supplier selection, and high-tech companies.

Skinner (1966) indicated some increases of competitive pressure on manufacturers. Profit, lower production costs, quality design, volume flexibility; and delivery speed are included in these pressures. Therefore, to evaluate the performance of manufactures may be based on the factors above. Wheelwright (1978) pointed out four criteria, including efficiency, dependability, quality and flexibility as the important factors for performance evaluation of manufacturing. Flynn et al. (1994) introduced some factors for evaluating the performance of manufacturing, including manufacturing cost, empowerment in employee, flexibility, and speed. Kasul & Motwani (1995) also introduced several criteria for performance measurements such as, efficiency, productivity, quality, management of material, improved technology, skill control, flexibility, price leadership, and global competitiveness.

3 Research Methods

DEA has been developed for 30 years since Charnes et al. (1978) developed the CCR model. Up to now the DEA methods have been used in various applications including education, health care (hospitals, clinics), agricultural production, banking, armed forces, sports, etc. (Emrouznejad, 1995). Further, at the same time, a lot of advanced models of DEA have been developed (e.g., cross-period data (Fare et al., 1985) and the multiple objective programming approach (Chiang and

Tzeng, 2000a, 2000b. 2003; Yu et al., 2004, 2007; Tsai et al., 2006). In this research, the traditional CCR, BCC DEA models as well as the MOP based on DEA model will be applied to aggregate the efficiency scores of the top information technology (IT) companies in S&P 500 based on the values as weights versus each input and output.

3.1 DEA

DEA is a non-parametric approach and doesn't need assumptions about the inputs and outputs. In 1957, Farrell first introduced how to deal with the problem of measuring the productive efficiency to both the economic theorist and the economic policy-maker (Farrel, 1957). The first DEA model, a mathematical programming model by Charnes, Cooper, and Rhodes in 1978, was built to discuss the efficiency frontier by Farrell (Charnes et al., 1978). The CCR model assumes that production exhibits constant returns to scale. Then, in 1984, Banker, Charnes, and Cooper, extended the CCR model by assuming variable returns to scale and named the new model as the BCC model (Banker et al, 1984).

For company managers, controlling the range of inputs and decreasing inputs is easier than increasing the total sales. The CCR and BCC models of DEA are often used the input-oriented.

3.1.1 CCR

CCR–DEA model computes relative efficiency scores h_k of k^{th} DMU $(k \in \{1,2,...,n\})$ based on selected s outputs $(r = 1,...,s)$ and m inputs $(i = 1,...,m)$ using the following linear programming expression (Charnes et al., 1978; Charnes et al., 1985; Chiang and Tzeng, 2000b):

$$\text{Max } h_k = \sum_{j=1}^{s} u_j y_{jk} \Big/ \sum_{i=1}^{m} v_i x_{ik} \tag{1}$$

Subject to

$$\sum_{j=1}^{s} u_j y_{jr} \Big/ \sum_{i=1}^{m} v_i x_{ir} \le 1, \quad r = 1,2,...,n$$

$$v_i, u_j \ge \varepsilon > 0; \; i = 1,2,...,m; \; j = 1,2,...,s; \; k, r \in \{1,2,...,n\}$$

In Eq. (1), it assumes the DMU (Decision Making Unit) has s outputs and m inputs, and there are n DMUs. The definition let x_{ik} be the i^{th} input (i =1,2,…,m) and y_{jk} be the j^{th} output (j =1,2,…,s) in kth DMU; the v_i and u_j are not zero, calculating as $v_i, u_j \ge \varepsilon > 0$, ε is non-Archimedean number and is 10^{-6} in this paper.

3.1.2 Correct CCR Based on BCC Model

Eq. (1) refers to maximize the ratio of weighted sum of output and input values. Then Charnes et al. (1987) proposed correct CCR model based on input-oriented BBC model (Banker et al., 1984) by Chiang and Tzeng (2000b):

$$\text{Max } h_k = \sum_{j=1}^{s} u_j y_{jk} \Big/ \sum_{i=1}^{m} v_i x_{ik} \tag{2}$$

Subject to

$$\sum_{j=1}^{s} u_j y_{jr} \Big/ \sum_{i=1}^{m} v_i x_{ir} \le 1, \quad r = 1,2,...,n$$

$$u_j \Big/ \sum_{i=1}^{m} v_i x_{ik} \ge \varepsilon > 0, \quad j = 1,2,...,s$$

$$v_j \Big/ \sum_{i=1}^{m} v_i x_{ik} \ge \varepsilon > 0, \quad i = 1,2,...,m$$

Since it is difficult to solve the fractional programming as Eq. (1) and Eq. (2), we transfer Eq. (1) and Eq. (2) to the linear programming by the following transformations:

Assuming $v_i^0 = t \cdot v_i$ (i.e., $v_i = v_i^0 / t$), $u_j^0 = t \cdot u_j$ (i.e., $u_j = u_j^0 / t$), $t^{-1} = \sum_{i=1}^{m} v_i x_{ik}$, then multiply the numerators and denominators in Eq. (1) by *t*, and add the consistency condition, $t\sum_{i=1}^{m} v_i x_{ik} = 1$. Thus Eq. (2) can transfer to Eq. (3).

$$\text{Max } h_k = \sum_{j=1}^{s} u_j^0 y_{jk} \tag{3}$$

Subject to

$$\sum_{j=1}^{s} u_j^0 y_{jr} - \sum_{i=1}^{m} v_i^0 x_{ir} \le 0, \quad r = 1,2,...,n$$

$$\sum_{i=1}^{m} v_i^0 x_{ik} = 1$$

$$u_j^0 \ge \varepsilon > 0, \quad j = 1,2,...,s$$

$$v_i^0 \ge \varepsilon > 0, \quad i = 1,2,...,m$$

$$v_i^0 = t \cdot v_i$$

$$u_j^0 = t \cdot u_j$$

$$t^{-1} = \sum_{i=1}^{m} v_i x_{ik}$$

The dual problem of Eq. (4) can be written as follows:

$$\text{Min } h_k = \left[\theta_k - \varepsilon \left(\sum_{i=1}^{m} S_{ik}^{-} + \sum_{j=1}^{s} S_{jk}^{+} \right) \right] \tag{4}$$

Subject to

$$\theta_k x_{ik} - \sum_{k=1}^{n} \lambda_k x_{ik} - S_{ik}^{-} = 0, \quad i = 1,2,...,m$$

$$y_{jk} - \sum_{k=1}^{n} \lambda_k y_{jk} + S_{jk}^{+} = 0, \quad j = 1,2,...,s$$

$$S_{ik}^{-},\ S_{jk}^{+},\ \lambda_k \ge 0$$

where S_{ik}^{-} and S_{jk}^{+} are slack variables.

The dual problem, presented by BBC (Banker et al., 1984), has two primary strengths, the reduction of calculation barriers and the provision of more helpful information for decision maker. S_{ik}^{-} and S_{jk}^{+} are slack variables of input criteria and output criteria respectively. When $h_k^* = 1$ an individual DMU_k achieves

Pareto's optimality, where "$*$" denotes for the optimal solution, for example, $\{(x_{ik}^*, y_{jk}^*) \mid S_{ik}^- = S_{jk}^+ = 0,\ \ i = 1,2,...,m;\ \ j = 1,2,...,s\}$, and $S_{ik}^- = S_{jk}^+ = 0$. If DMU has not achieve Pareto's optimality situation, its limited equation intrinsically includes $x_{ik}^* = \theta^* x_{ik} - S_{ik}^-$ and $y_{jk}^* = y_{jk} + S_{jk}^+$. In order to achieve its efficiency goal of optimality, this specific DMU may either reduce inputs $\Delta x_{ik} = x_{ik} - x_{ik}^*$ or increase output $\Delta y_{ik} = y_{ik}^* - y_{ik}$ to become efficient in the relative efficiency. Clearly, the slack variables analysis of DEA method provides DMU's with related information of range and direction for improvement in ideas. When a DMU does not achieve Pareto's optimality, we can make some improvement or innovation/creativity based on Eq. (4) in consideration. Then this results can help individual DMU how we can achieve Pareto's optimality in the relative efficiency, i.e.,

$$x_{ik}^* = \theta^* x_{ik} - S_{ik}^-, \quad i = 1,2,...,m$$
$$y_{jk}^* = y_{jk} + S_{jk}^+, \quad j = 1,2,...,s$$

3.2 Multiple Objective Programming Based DEA

Multiple objective programming (MOP) based DEA method provides a unitary weight (u^*, v^*) for all DMUs, which are evaluated by considering an equal standard measure (Chiang and Tzeng, 2000a, 2000b; Yu et al., 2004, 2007). By this approach, this research can obtain the efficiency rating of each DMU more fairly. Moreover, all DMUs can be treated simultaneously, which makes it effectiveness in handling large numbers of DMU.

Model 1

$$\left.\begin{array}{l} \text{Max } z_1 = \sum_{j=1}^{s} u_j y_{j1} \,/\, \sum_{i=1}^{m} v_i x_{i1} \\ \vdots \\ \text{Max } z_k = \sum_{j=1}^{s} u_j y_{jk} \,/\, \sum_{i=1}^{m} v_i x_{ik} \\ \vdots \\ \text{Max } z_n = \sum_{j=1}^{s} u_j y_{jn} \,/\, \sum_{i=1}^{m} v_i x_{in} \end{array}\right\} \tag{5}$$

Subject to

$$\sum_{j=1}^{s} u_j y_{jk} \,/\, \sum_{i=1}^{m} v_i x_{ik} \le 1, \quad k = 1,2,...,n$$
$$v_i, u_j \ge \varepsilon > 0, \quad i = 1,2,...,m;\ \ j = 1,2,...,s$$

4 Empirical Study

By assuming the similarity of the firms may bias the results. When using the same standard to evaluate the performance of companies; however the difference including products, life cycle etc. of the companies being as DMUs is so critical, the equal standard seems to be a big problem on this research. Thus, the author tried to select the firms with equal character and field being as DMUs. The author

chooses services-prepackaged software firms in S&P 500 index as DMUs to evaluate the performance. These companies include Adobe Systems Inc., Autodesk Inc., BMC Software, CA, Inc., Citrix Systems, Compuware Corp., Electronic Arts, Intuit Inc., Microsoft Corp., Oracle Corp., Salesforce.com, and Symantec Corp.

Cost of revenue and R&D expense have been selected as inputs while total revenue, Return on Investment (ROI) as well as net income growth have been selected as outputs. Based on the CCR DEA, Autodesk Inc, BMC Software, CA, Inc., Citrix Systems, as well as Compuware Corp. are 100% efficient. On the other hand, by using the novel MOP approach, Autodesk Inc., BMC Software, Citrix Systems still has achieved the optimum efficiency of 100%. Both results of CA, Inc. and Compuware Corp. are significant different form CCR DEA and MOP based DEA. (Please refer to Table 1 for the empirical study results.) This empirical study demonstrates that performance evaluation results based on CCR DEA or the novel MOP are different especially in some DMUs.

Table 1 Evaluation of Services-Prepackaged Software firms in S&P 500 index by CCR and MOP Based DEA

No.	DMU	CCR	Rank	MOP	Rank
1	Adobe Systems Inc.	0.977	6	0.977	4
2	Autodesk Inc.	1.000	1	1.000	1
3	BMC Software	1.000	1	1.000	1
4	CA, Inc.	1.000	1	0.975	5
5	Citrix Systems	1.000	1	1.000	1
6	Compuware Corp.	1.000	1	0.681	10
7	Electronic Arts	0.344	12	0.344	12
8	Intuit Inc.	0.798	9	0.775	8
9	Microsoft Corp.	0.796	10	0.770	9
10	Oracle Corp.	0.686	11	0.674	11
11	Salesforce.com	0.898	8	0.837	7
12	Symantec Corp.	0.943	7	0.890	6

5 Discussion

In the following section, both theoretical advances of the MOP based DEA approach as well as managerial implications will be discussed. At first, the novel MOP based DEA approach, can really provide a totally different result based on the assumptions of fair weights versus each input and output. For example, CA, Inc. and Compuware Corp. have been shown less efficient based on MOP based DEA; however, both firms have been indicated 100% efficient based on CCR DEA. The successful introduction of the min-max approach resolved the traditional DEA model successfully. Apparently, this novel MOP model can be considered as a better alternative to the traditional CCR DEA.

In the past, people seldom developed an evaluation model especially by using DEA for the services-prepackaged software firms. Thus, this research defined a feasible framework for evaluating the services-prepackaged software firms which can be leveraged as the basis for government policy and firm level investment, R&D and competitive strategy definitions. Further, the novel MOP based DEA approach demonstrated different results to the traditional CCR DEA. In the empirical study, the MOP based DEA demonstrated that Autodesk Inc., BMC Software, and Citrix Systems should be the services-prepackaged software firms to invest. Meanwhile, based on the MOP based DEA results, firms including Compuware Corp., Electronic Arts, Intuit Inc., Microsoft Corp., as well as Oracle Corp. are still far less than efficient. Appropriate adjustments of both inputs and outputs are required to enhance their competitiveness.

6 Conclusions

The information technology is one of the popular industries at the moment due to IT is starting to spread further from the conventional personal computer and network technologies to integrations of other fields of technology such as the use of cell phones, televisions, automobiles, etc. Albeit important, very few researches tried to define an evaluation framework for IT especially in services-prepackaged software firms. This research bridged the gap and introduced a novel MOP based DEA approach which overcame the shortage of the traditional CCR DEA model. Based on the evaluation results, Autodesk Inc., BMC Software, and Citrix Systems are the most efficient services-prepackaged software firms. The evaluation results can serve as the basis for investment strategy definitions.

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Hot Fomentation of the Lower-Back for Stress Relief in Students Preparing for a National Examination of Clinical Medical Technologist

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Abstract. The objective of this study is to propose a method of hot fomentation for a lower-back care for stress relief. Experimental evidence statistically validated this approach for relieving stress. In the experiment, hot fomentation was applied to twenty senior college students (from 21 to 22 years old) who had complained of stiffness in their shoulder and lumbar region of the back during the month prior to a national examination for clinical Medical technologist. Before and after the 30-minute hot fomentation care with a hot-pack, we measured their psychological and physical reactions. The changes in their psychological reactions

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were evaluated using the visual analog scale (VAS) to assess the degree of comfort. The physical reactions were evaluated using the cortisol level of blood serum as an index of stress.

(1) The experimentally determined VAS values indicated that hot fomentation significantly relieved stress.
(2) The cortisol level of blood serum (a proven neuroimmunological index of stress) decreased significantly following the hot fomentation care.
(3) However, both the changes of VAS values and the cortisol level changes of blood serum are not significantly correlated.

We found that lower-back hot fomentation by a hot-pack provided a significant stress relief effect, both mentally and physically, for the 20 students who planned to take a national examination of Clinical Medical technologist. However, both the psychological and physical outcomes were not significantly correlated. This lack of correlation indicates that the anxiety relief might exceed the physical stress relief.

Keywords: Hot fomentation, Hot-pack, Lower-back portion, Visual analog scale, VAS, the cortisol level of blood serum, National examination, laboratory technologist.

1 Introduction

It is currently well known that various types of stress produce great burdens on human lives and behaviors. The objective of this study is to propose lower-back hot fomentation care as a method for stress relief. Stress can be measured using both psychological and physical methods. The visual analog scale (VAS) of comfort-discomfort can be used to psychologically evaluate the stress level of a patient according to the degree of comfort or discomfort. The cortisol level of blood serum is used as a stress index to evaluate the physical degree of stress. This study reports the result of an attempt to reduce a patient's stress using a 30-minute hot-pack hot fomentation for a lower-back care.

In Japan, all healthcare professionals must obtain national approval to begin their careers in medicine. That is, final-year students of medical technology cannot start working without passing the national examination, and therefore all of the final-year students take the national examination. All of the medical technology students endure a long period of mental stress because of the clinical exercises and internship they undertake at a medical care facility and the education program they receive at school. Furthermore, universities provide various countermeasures in the education program to help ensure that all of the students pass the national examination. The number of students who pass the test influences the evaluation of university quality. Therefore, university staff helps their students prepare as best as possible.

Various reports and papers have considered the preparation for the national examination in Japan, such as support of the students and the educational program staff. However, the level of stress endured by a student during his/her preparation for the national examination or how a student can be relieved of the various kinds of stress is unknown.

In this paper, we propose lower-back hot fomentation as a stress relief method. This approach to stress relief is validated on senior students from 21 to 22 years old who will take a national examination for clinical Medical technologist in a month. After a 30-minute hot fomentation care using a hot-pack, the experiment to examine the psychological and physical conditions of all the subjects who had felt stiffness in their shoulders and in the lumbar region of their backs was undertaken. The psychological evaluation used a visual analog scale (VAS), which assesses the degree of comfort or discomfort. The physical evaluation used the cortisol level of blood serum as an index of stress. (1) The experimentally determined VAS values outcome indicated that hot fomentation significantly relieved stress. (2) The cortisol level of blood serum (a proven neuroimmunological index of stress) decreased significantly following the hot fomentation care. (3) However, the changes in the VAS values and the cortisol level changes of blood serum are not significantly correlated.

2 Research Method

2.1 Subjects

The subjects in this experiment were senior college students, from 21 to 22 years old, in the School of Clinical Laboratory Technology, University A, who complained of stiffness in the shoulder and lumbar region of the back. They planned to take a national examination for clinical Medical technologist a month after the experiment.

2.2 Ethical Considerations in Primary Research

\The primary research was conducted with the approval of the ethics review committee of University A after our submission of the required document (Approval Number of Experiment 20-51 of the Ethics Review Committee).

After initially explaining the objective of the research and experiment to the subject students in both oral and written forms, the subjects underwent the experiment when the approval and agreement between the subjects and the experiment staff were obtained. Furthermore, in the experiment, we gave sufficient considerations to the following requirement:

(1) The personal information is sufficiently protected so that is cannot identify an individual.
(2) The biographical data are not used for any purpose other than this research.

2.3 Experimental Method

The experiment was performed in a laboratory at University A from 18:00 to 20:00 in the middle of January 2011; the care was provided to students who would take the national examination of clinical Medical technologist in a month. While the students lay on a bed for 30 minutes, hot-packs were placed on the part of the

back corresponding to the second vertebrae cervicales CII to the forth lumbar vertebra. Before and after this care, VAS assessments were given, and blood samples were taken.

(1) The hot-packs used were DeRoyal Sofsorb Absorbent Pads & Sheets (Duro-Med Industires, Inc., USA) that are applied when their centers reach a temperature of 45 degree Celsius by heating in a microwave oven. Each hot-pack, which is 40 degree Celsius on the surface, is covered with a dry towel. After informing each subject, their entire back from the posterior neck and vertebra prominens CVII to both shoulders and the third and fourth lumbar vertebrae is covered with the sheet.
(2) The cortisol level of the blood serum is used as a neuroimmunological index to measure physical stress. All of the students had blood samples drawn just before and after the care.
(3) The VAS was used as an index to measure the psychological response of the subjects. In the VAS, "the most uncomfortable feeling" was assigned to 10 in the scale, and "the most comfortable feeling" was assigned to 1.
(4) The ambient temperature of the room was set to 25 ±2 degrees Celsius with a natural sound state and without any conversation.

2.4 Statistical Analysis

Using a non-parametric Wilcoxon signed-rank test, the cortisol level of blood just before and after the care and the VAS results are tested for significant differences. We also calculated the Fisher's correlation between the cortisol level and the VAS to test the significance of their correlation.

3 Results

3.1 The Change in Cortisol Levels Caused by a 30-Minute Hot-Pack Care

For the 20 senior students (21 to 22 years old) who experience stiffness in the shoulder and in the lumbar region of the back and who will take a national examination for clinical Medical technologist in a month, the cortisol levels of blood serum were $8.4 \pm 0.9\ \mu g/dl$ and $6.0 \pm 0.9\ \mu g/dl$ before and after the 30-minute hot fomentation for a lower-back care using a hot-pack, respectively. These data were significantly different ($p < 0.001$), as indicated by Figure 1.

3.2 The Change in Psychological Responses Caused by a 30-Minute Hot-Pack Care

For the 20 subjects, the psychological response of the VAS values were 6.3 ± 0.3 and 4.6 ± 0.5 before and after the 30-minute lower-back hot fomentation care,

respectively. These data were significantly different ($p < 0.01$), as indicated by Figure 2.

3.3 Correlation Coefficient between the Cortisol Levels and Psychological Responses

For the 20 subjects, the correlation coefficient of the care-induced changes between the VAS values of the psychological responses and the cortisol levels of blood serum was 0.3, p=0.5. The values are not significantly correlated.

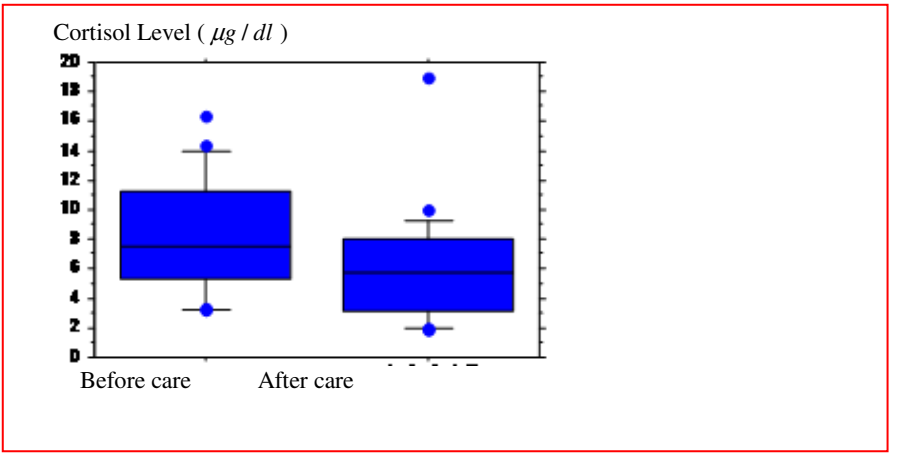

Fig. 1 Change in the mean cortisol level caused by a 30-minute hot-pack care

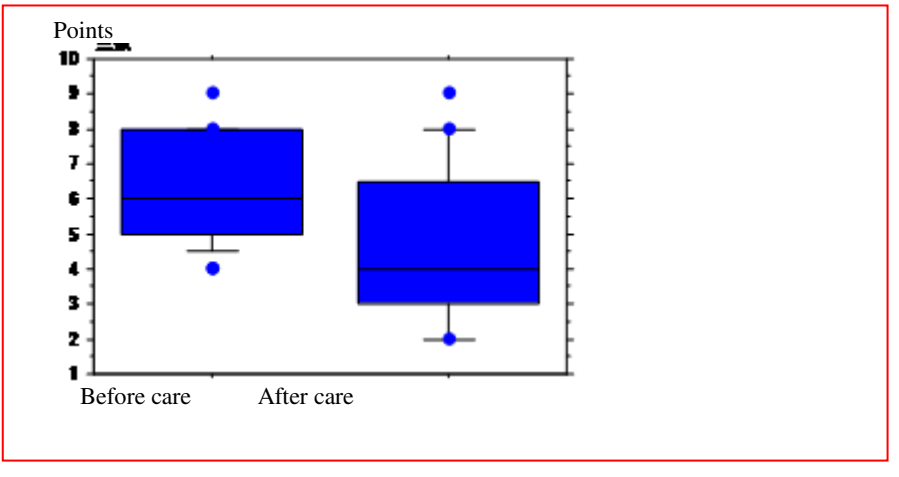

Fig. 2 Change in the mean VAS value caused by a 30-minute hot-pack care

4 Discussion

4.1 The VAS Evaluation of the Psychological Influence of Hot Fomentation Care

Using the VAS, the psychological state of the subject was measured before and after the hot fomentation care for the 20 subject students who were experiencing stiffness in the shoulder and the lumbar region of the back one month before the national examination of clinical Medical technologist. The VAS value dropped from 6.2 to 4.6. This change indicated that the heat-retaining effect of the lower-back care relieved the unpleasant emotions and stress and led to a more comfortable psychological response. The hot-pack care relieved stress and pain by thermal heating of the back, and the VAS values decreased. Hasebe (2005) [1], Matsushita (2008) [2], and Kubo *et al.* (2011) [3] reported that hot fomentation care using a hot-pack increases the blood flow volume of subjects and mitigates shoulder and loin stiffness. For psychological aspects, Buttagat *et al.* (2012) [4] reported that hot-pack fomentation care is capable of increasing the feeling of comfort and enhancing relaxation.

4.2 The Stress Index As Determined by the Blood Serum Cortisol Level

Stahl and Dorner (1982) [5] reported that physical stressors increase the cortisol concentration of blood serum. As senior students have been preparing for their national examination of clinical Medical technologist for a long period of time, they have experienced continuous psychological stressors. In particular, just before the national examination, they must spend many hours in preparation. Students sit in a chair for 6 to 8 hours a day, leading to stiffness in the shoulders and the lumbar region of the back those results from maintaining this position. Furthermore, they endure additional stressors caused by the anxiety around the results of the national examination, which causes much psychological and physical burden.

The lower-back fomentation care by a hot-pack decreased the blood serum cortisol level and significantly affected the national examination stressors. In general, the stress response can be understood to involve two response systems: (1) the endocrine system of the hypothalamic-pituitary-adrenal cortex axis and (2) the autonomic nervous system of the hypothalamus-pons-medulla oblongata-spinal marrow-adrenal medulla axis. The endocrine cortisol level of the blood serum serves as an effective index of stress. Pani *et al.* (2011) [6] reported that the cortisol level increases in response to psychological stress but decreases in response to comfortable stimuli. Al-Ayadhi (2005) [7] reported that the uncomfortable and tense state of sympathetic hyperactivity produced by stressors was changed into a comfortable state using a hot-pack fomentation care and that, furthermore, the biological response of the autonomic nervous system was recognized. Fredrickson and Levenson (1998) [8] clarified that the heat retention affected activation of the parasympathetic nervous system and inhibition of sympathetic hyperactivity. In this

paper, we report that a hot-pack fomentation care can increase comfortable stimuli and decrease the cortisol level of blood serum, in agreement with the above reports. We believe that the hot-pack fomentation care provides stress relief.

4.3 The Relationship between the Blood Serum Cortisol Level and the VAS Value of Psychological Response

In this study, the stress relief by lower-back hot fomentation using a hot-pack was examined using the cortisol level of blood serum as a stress index and VAS values as a measure of the psychological response. After treating the subject with hot-packs on lower-back portion, the decrease in cortisol level and VAS values are recognized but the correlation between both the change of the cortisol level and the change of the VAS values was not significant. In general, hot fomentation produces relaxation and decreases the cortisol level of blood serum. Pawlow and Jones (2005) [9] also observed decreases in VAS values, as did Yamamoto and Nagata (2011) [10]. The hot fomentation care of the lower-back promotes the recovery from uncomfortable stress and creates a more comfortable state, inhibits the activities of skin sympathetic nerves and, as a result, improves the peripheral circulatory state. These effects relax the mind and body to rest after the burden of stress, as Watanabe *et al.* (2006) reported [11]. Nevertheless, the correlation between the cortisol level change and the VAS value change were not significant An explanation for this lack of correlation might be that the national examination for students causes a greater amount of anxiety and tension than the amount of relaxation provided by the lower back hot fomentation. Furthermore, statistically, the value of the cortisol level is more precise (one tenth of one percent), but the psychological VAS values are less precise because they employ discrete values from 1 to 10 on a scale of 10. Therefore, another psychological scale should be employed.

5 Conclusions

This paper reported the result of analysis of relief stress using a 30-minute hot fomentation care with a hot-pack on the lower-back of subjects. This method was applied to final-year students of medical technology who cannot begin working until they pass their exam. The experiment attempted to examine the psychological and physical states of the subjects who were experiencing stiffness in the shoulder and the lumbar region of the back. The psychological evaluation was performed using a visual analog scale (VAS) to assess the degree of being comfort or discomfort. The physical evaluation consisted of measurements of the blood serum cortisol level as an index of stress. The result showed that (1) VAS values indicated the effective relief of stress, (2) the cortisol level of blood serum as a neuroimmunological index is significantly decreased and (3) but the correlation between the VAS value change and the cortisol level change was not recognized significantly.

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Hybrid MCDM Model for the Value Evaluation of the Restoration of Historical Objects

Mei-Chen Lo, Tadeusz Trzaskalik, Maciej Nowak, Tian-Jong Hwu, Gwo-Hshiung Tzeng, and Jerzy Michnik

Abstract. As time goes by, every historic object dilapidates and wears out. As the result, the values that it used to represent become obliterated and its effete on the public is weakened. Conservation and restoration of art works aim at preserving the extant matter and, if possible, at bringing the antiques to their former glory in historical value; the more so that the historical value of the objects also increases with time. Conservators' work, independently of their special fields of interest, should be preceded by research whose goal is the determination of the guidelines for the conservation efforts and the selection of the best methods of action in interdependence and feedback among dimensions and criteria. A thorough analysis determines several possibility methods of action, emphasizing various groups of values. In this study, a hybrid Multiple Criteria Decision Making (MCDM) model based on DNP (DEMATEL-based ANP) is used to assess the historical objects relative values viewed by different groups of experts in inter-relationship problem of real world. The procedures provide a reference guide of improvement directions and efficient art work reservation of historical objects for achieving the aspiration levels.

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Keywords: Hybrid Multiple Criteria Decision Making (H-MCDM), historical portable organ, art restoration, value analysis, DNP (DEMATEL-based ANP), aspiration level.

1 Introduction

As time goes by, every historic object dilapidates and wears out. As the result, the values that it used to represent become obliterated and its effete on the public is weakened. Conservation and restoration of art works aim at preserving the extant matter and, if possible, at bringing the antiques to their former glory; the more so that the historical value of the objects increases with time.

Conservators' work, independently of their special fields of interest, should be preceded by research whose goal is the determination of the guidelines for the conservation efforts and the selection of the best methods of action. Inventory, documentation and research efforts are completed by a value analysis whose purpose is to precisely define several values of the object so as to emphasize and reveal the most important of them. A thorough analysis determines several possible methods of action, emphasizing various groups of values. The basic value groups of historic objects and monuments have been formulated by Walter Frodl [2]. These groups, expanded by musical issues, are used in this paper.

The possibility of a variant-based approach to the issue of the value analysis of historic items suggests that the methodology of the multi-criteria decision support can be used for the selection of the best variant of conservation method of the individual item or monument. The possibility of shaping the selected values after the reconstruction of the object allows regarding the values as decision criteria. Possible ways of the instrument reconstruction constitute here decision variants.

In the 17^{th}- and 18^{th}-century Poland the portable organ, called the positive organ, was a very popular instrument'; almost every parish was equipped with one. It was not on1y a church instrument, since the portab1e organ was used a1so to accompany dancers in ballrooms. Its popularity was due above all to the ease of hand1ing and the possibility of easy transportation. Unfortunately, on1y 18 copies of this once so common instrument are nowadays extant in Poland (according to current research). One of the extant instruments from this group, found only recently, comes from Sokoły near Łapy in the Podlasie region of Poland. For many years the instrument had been stored disassembled, undergoing atmospheric and biological damage. Its condition made it impossible to use it either as a visual historic item ("piece of furniture") or as a musical instrument. Such condition is called in Polish conservation science terminology a "destrukt".

The value analysis of historic items is not on1y a theoretical consideration, but aims at determining the guidelines of conservation efforts and, in connection with experience and conservation science, allows for the selection of the best conservation methods for individual works of art. The precise estimation of value of the extant elements of the instrument became thus a research problem; on this basis the determination of several (10 to 20) variants of conservation programs will be

made. The purpose of this paper is the joint application of the analysis evaluating an historic organ and the MCDM method in the selection of the guidelines for conservation efforts in the case of the recently discovered organ.

This paper consists of five sections. In Section 1 selected problems related to the analysis for the evaluation of an historic organ are described. Specified groups of values have been used for the construction of decision criteria. The history and original condition of the instrument in question have been described in Section 2. Possible methods of restoration of this instrument, treated as decision variants in multivariate analysis, have been presented in Section 3. Section 4, the hybrid MCDM method is described and presents the application of the MCDM method proposed for the analysis of the problem in question, and Section 5, conclusions following from it.

2 About the Historical Organ

The first person to recognize and define the value of a separate group of historic objects - historic musical instrument s - was the German scholar and musician Albert Schweitzer'. Thanks to his authority the cause of preservation of historic organs gained many advocates among musicians as well as conservators and researchers.

The value analysis of historic objects, used nowadays in conservation science with respect to all kinds of historic objects and monuments, has been defined by Walter Frodl in the middle of the 20th century, and was subsequently expanded and completed [3]; in the Polish legislation it resulted in an act concerning the preservation and protection of historic monuments [1].

According to this document an "historic monument or object" is "a building or an object, its element or subsystem, man-made or related to human activities which are an evidence of an epoch or an event from the past, whose preservation is of social value due to its historic, artistic or scientific value". Taking into account the synthetic character of the group of objects dealt with in this paper, historic organs, a precise definition of such values will help improve value analysis.

2.1 Values of an Historical Organ as Decision Criteria

In the following discussion suggest a division of the values of historical organs into four groups: historic [6] and [7], artistic, musical and utilitarian values. We will now describe the values constituting each of the four groups.

Historic values determine the character of the object as a document and its influence on the development of historical knowledge. Among the values of this group are *scientific values,* due to the fact that an organ is an historic object, requiring a scholarly description. Also in this group are *technical values,* determining the ingenuity of the construction, the quality of the workmanship and the scientific value of its current condition. Also *historic emotional values,* perceived not only by scientists and scholars, but also by the public at large, belong here.

The *ownership values,* i.e., values stemming from the ownership of the original item (without hypothetical additions) are connected with honest approach of the conservators to the historic object, in which that what is preserved should be emphasized above all, as opposed to that what we think might have been there. The group of *artistic values* is related to the perception of historic organs as works of art, and this is connected with the instrument's case. To this group belong *historic-artistic values,* determining whether the solutions chosen by the builders are typical or atypical as well as the importance of the original, its copy or its hypothetical reconstruction.

Artistic qualities affect the public independently of the current fashion or style. The *artistic effect* of the ease of historic organ should match musical impressions received by the audience from the musical compositions heard by it. *Musical values* become apparent during a musical performance. This study deals here with the issue of style *(historical musical value)* and of sound *(musical quality).* All of them taken together may reinforce the *musical influence* on the amateur listener. It can happen that the regaining of musical value and the preservation of the original technical solutions are conf1icting goals. In such case we face the problem of *utilitarian values* of the historic instrument. The notions of live organ and dead organ are related to this group of values. A *musically dead organ* is an instrument that nowadays cannot fulfill its function of a musical instrument. A *live instrument* is an instrument capable of being used in musical performance, affecting the audience in various ways. Like any historic object, an organ as a piece of furniture can be also visually dead - not suitable for being exhibited, or else visually alive (independently of its musical "vitality") - beautiful, but unplayable.

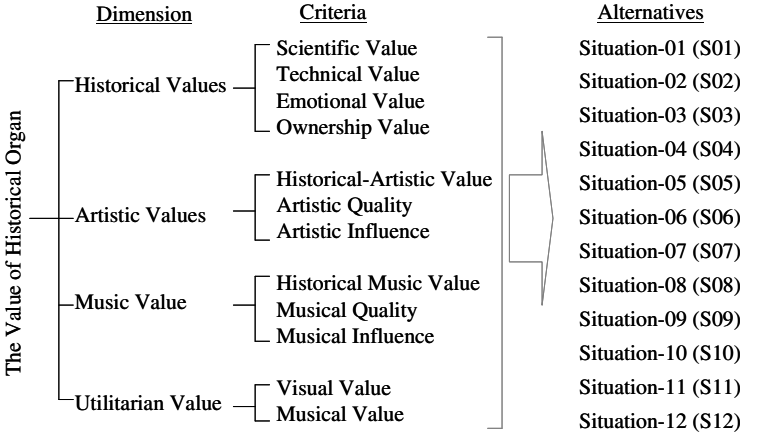

Fig. 1 The Value Structure of Historical Organ

Therefore, the value structure above (Fig. 1) is constructed and used as decision criteria in the problem of the selection of the best conservation alternatives/situations, discussed below. The decision criteria admit the values from 0 (lowest grade) to 4 (highest grade). The decision situations (alternatives) defined

later in the paper will be evaluated by experts, utilizing during the evaluation according to his or her expertise of the topic.

3 The Instrument Undergoing the Restoration

The basic feature distinguishing a portable organ from a stationary one are its small dimensions and a design allowing for placing of all elements characteristic for the organ-like instrument s (pipes, wind chest, action, bellows) in a small, easy to handle case. The "compression" of the instrument's mechanism is achieved by making the dimensions of the wind chest as small as possible, restricting the action to the direct transfer of the movement from the key to the pallet and mitering (often repeated) of the pipes or the use of common side walls of wooden pipes. Bellows of small dimensions always require a certain space for proper functioning, and that is why they are located on the instruments, underneath, or next to the case wall opposite the keyboard. The placing of the keyboard is also related to the localization of the bellows, which follows from the construction of the wind chest.

The positive organ from Sokoły is an instrument of the two-chamber type, in which the lower one (larger) contains two wedge bellows, while the upper one (smaller), wind chest, pipes and keyboard. It is characteristic for this instrument that the lower chamber cover can be taken out and, after the bellows have been blocked, the upper chamber can be inserted into the lower one. Once this "package" is closed, the instrument is secured and can be transported conveniently. After the arrival at its destination, a two-part positive organ, when taken apart, is independent and does not require any auxiliary furniture.

The positive organ from Sokoły is preserved as a non-functional and visually unattractive object ("destrukt") - each element was stored separately and individual parts were damaged. About 70% of the case, 90% of the mechanism and 10% of the sound system have been preserved. In this condition the value of the positive organ is recognizable by a narrow group of researchers who are able to visualize how to combine the individual parts.

3.1 Possible Methods of Instrument Restoration

As this study further work on the possible methods of instrument restoration as decision alternatives [8]. On the basis of research and evaluation of the condition of the individual parts of the instrument (or their lack) 12 renovation treatments of the rediscovered instrument have been suggested.

- *Situation I* (S01): Preservation of the instrument as a non-functional, visually unattractive object ("destrukt") and its exhibition in the form of a group of museum exhibits.
- *Situation II* (S02): Integration of the elements of the instrument using racks necessary to place the individual elements in proper places.
- *Situation III* (S03): Integration of the parts of the instrument with full completion of the construction elements of the case; completion of the missing parts of the mechanism. The pipes remain secured, but do not play.

- *Situation IV* (S04): Integration of the parts of the instrument with full completion of the construction elements of the ease according to their former shape. The pipes remain secured, but do not play.
- *Situation V* (S05): Integration of the parts of the instrument with full completion of the construction elements of the case; completion of the missing parts of the mechanism. Reconstruction of the polychrome. The pipes remain secured, but do not play.
- *Situation VI* (S06): Integration of the parts of the instrument with full completion of the construction elements of the ease. Bringing the extant pipes to working condition and reconstruction of the missing pipes, so as to match the sound capabilities of the extant pipes.
- *Situation VII* (S07): Visually, the object is moderately attractive; utilitarian musical value appears, especially for people appreciating the original, historical sound. Exhibition of the extant historic pipes in a display ease without giving them their former technical functionality. Reconstruction of the entire sound system according to preserved models.
- *Situation VIII* (S08): Integration of the parts of the instrument with full completion of the construction elements of the ease according to their former shape. Bringing the pipes to a working condition and reconstruction of the missing pipes, so as to match the sound capabilities of the extant pipes.
- *Situation IX* (S09): Integration of the parts of the instrument with full completion of the construction elements of the ease according to their former shape, Exposition of the extant historical pipes in a display eases without bringing them to a working condition. Reconstruction of the whole sound system according to preserved models.
- *Situation X* (S10): Integration of the parts of the instrument with full completion of the construction elements of the ease according to their farmer shape. Bringing the pipes to a working condition and reconstruction of the missing pipes so as to match the sound of the sound capabilities of the preserved pipes.
- *Situation XI* (S11): Integration of the parts of the instrument with full completion of the construction elements of the case according to their former shape. Exhibition of the preserved historic pipes in a display case without bringing them to a working condition. Reconstruction of the whole sound system according to preserved models.
- *Situation XII* (S12): Preservation of the instrument in its non-functional, visually unattractive condition (as a "destrukt"). Making of an accurate copy. The evaluation focuses on the values of the copy, which is presented to the public.

The possible actions and results which caused by each different situation, it has made under the value evaluation by experts. Although, each of the result from different situation, it may guide different perception on the historic organ to be performed later; and the expectation of the restoration work display in the degree of its original states.

4 Methodologies of MCDM

This section is aimed to understand the evaluation indexes of the value of restoration historical organ. It is collected, selected, analyzed, simulated and tested by the literature and expert questionnaires to find the usefulness and the promotion spots as a basis. Lo & Tzeng [4] indicate that MCDM is a methodology that is able to consider multiple criteria at the same time and also helps the decision- maker to

estimate the best case by sorting cases according to the characteristics or criteria ([4], [11], [9], [10]) of each from limited available cases.

4.1 Empirical Analysis

In this study, according to the literature review and expert experiences, an value evaluation system including four dimensions and 12 criteria that will exert an influence on alternative selection of restoration historical organ is established, as given in Table 4.1. A survey was conducted via questionnaires distributed to several groups comprised of the experts' knowledge and background. Their ratings for each criterion's relationship to sustainable development using a five-point scale ranging from 0 (no effect) to 4 (extremely influential) were collected.

This set of criteria provides this study with an overall evaluation system that facilitates further prioritization by the concept of ANP [5]. According to Table 1, the critical factors for value evaluation on restoration of historical organ which is including "Musical-utilitarian value (C_{42})", "Visual-utilitarian value (C_{41})", "Historical-musical value (C_{31})", "Historical-artistic value (C_{21})", "Artistic quality (C_{22})",and "Musical quality (C_{32})" according to the sequence (priority) of these factors from the calculation of ANP concept.

The MCDM model refers to making decisions in the presence of multiple, and often simultaneously faced/managed multiple criteria/objectives with critique criteria in real world. This study adopts MCDM approaches subject to calculate the weights and ranking that is used to solve the decision problem for the priority of value evaluation on restoration historical organ. We applied the influence matrix to compromise the trade-off between value aspects and situations' concerns. The main survey objects engage for the value in four phases (such as, values to Historical, Artistic, Music and Utilitarian), within related areas of experts or scholars who are senior in their domain knowledge and experiences on the evaluations work.

Table 1 The evaluation criteria

Aspects/Dimensions		Criteria	Weight
C_1 Historical Values	C_{11}	Historical-scientific value	0.057
	C_{12}	Historical-technical value	0.064
	C_{13}	Emotional value	0.076
	C_{14}	Ownership value	0.053
C_2 Artistic values	C_{21}	Historical-artistic value	0.086
	C_{22}	Artistic quality	0.084
	C_{23}	Artistic influence	0.080
C_3 Music values	C_{31}	Historical-musical value	0.093
	C_{32}	Musical quality	0.082
	C_{33}	Musical influence	0.075
C_4 Utilitarian values	C_{41}	Visual-utilitarian value	0.111
	C_{42}	Musical-utilitarian value	0.139

According to Table 2, the prominence $(d_i + r_i)$, "Historical Values (C_1)" is the highest impact of the strength of relation that means the most important influencing factors; in addition, "Utilitarian Values (C_4)" are all the factors that affect the least degree of other factors. According to the relation $(d_i - r_i)$, we also can find "Music Values (C_3)" is the highest degree of impact relationship that affects other factors directly. These dimensions also have the interact characteristics. Opposite, "Historical Values (C_1)" is the most vulnerable to impact that compare with other dimensions.

A grade of value from 0 (lowest grade) to 10 (highest grade) has been made by the set of experts' value evaluations, shown as Table 3. Each situation/alternative is depending of the values that the instrument would gain after the reconstruction according to the given decision situation.

Table 2 Influence Evaluation by dimension

	C_1	C_2	C_3	C_4	***D***	***d+r***	***d-r***	Rank
C_1	0.067	0.045	0.046	0.049	0.206	0.475	-0.062	4
C_2	0.068	0.048	0.068	0.057	0.242	0.458	0.025	2
C_3	0.067	0.066	0.050	0.065	0.248	0.456	0.039	1
C_4	0.065	0.057	0.045	0.030	0.197	0.397	-0.003	3
R	0.268	0.216	0.209	0.200	--	--	--	--

Table 3 Value Evaluation by Criteria

	Criteria	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12
C_{11}	Historical-scientific value	10	8	6	6	6	6	6	6	6	6	6	0
C_{12}	Historical-technical value	4	6	10	8	8	6	10	6	10	6	10	0
C_{13}	Emotional value	10	10	10	8	6	10	6	6	4	4	2	0
C_{14}	Ownership value	10	10	10	9	5	8	5	9	4	5	0	0
C_{21}	Historical-artistic value	0	2	4	6	6	4	4	6	6	8	8	0
C_{22}	Artistic quality	0	0	2	4	8	2	2	4	4	8	8	8
C_{23}	Artistic influence	2	2	6	8	10	6	6	8	8	10	10	10
C_{31}	Historical-musical value	0	0	0	0	0	10	4	10	4	10	4	4
C_{32}	Musical quality	0	0	0	0	0	8	10	8	10	8	10	10
C_{33}	Musical influence	0	0	0	0	0	8	10	8	10	8	10	10
C_{41}	Visual-utilitarian value	2	4	6	8	10	6	6	8	8	10	10	10
C_{42}	Musical-utilitarian value	0	0	0	0	0	8	10	8	10	8	10	10

The value evaluation by situations/alternatives is demonstrated as Table 4. Thus, two alternatives, S10 and S11 get the best evaluation. Thus, the sequence of performance of value evaluation is S10, S11, S08, S09, S06, S07, S12, S04 and then, S03, S05, S02, S01. As continuing lowering the value of the concordance threshold does not result in generating more detailed information, so the procedure and propose the decision making is recommended, as it has got the best evaluation in all rankings that have been constructed.

Base on these empirical results, we construct the network relationship map of each dimension as shown in Fig.2. It illustrates the critical problems in evaluating the restoration work on historical organ which including "Music Values (C_3)", "Artistic Values (C_2)" and "Utilitarian Values (C_4) which are easily impacted by other factors. Therefore, this model provides the direction of problem solving from "Music Values (C_3)", "Artistic Values (C_2)" and "Utilitarian Values (C_4). Some criteria take more effort on placing strategies are suggested according to experts' verification, such as Historical-Artistic Value, Historical Music Values, Musical Quality, Artistic Quality, Artistic Influence, Emotional Value, etc.

Table 4 Value Evaluation by Situations/Alternatives

	Criteria \ Alternatives	Local weight	Global weight	Aspired Level	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10	S11	S12
C_1		0.25			8.47	8.52	9.08	7.75	6.30	7.64	6.81	6.64	5.99	5.18	4.53	0.19
	C_{11}	0.23	0.06	10	10.00	8.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	0.00
	C_{12}	0.25	0.06	10	4.00	6.00	10.00	8.00	8.00	6.00	10.00	6.00	10.00	6.00	10.00	0.00
	C_{13}	0.30	0.08	10	10.00	10.00	10.00	8.00	6.00	10.00	6.00	6.00	4.00	4.00	2.00	0.00
	C_{14}	0.21	0.05	10	10.00	10.00	10.00	9.00	5.00	8.00	5.00	9.00	4.00	5.00	0.00	0.90
C_2		0.25			0.64	1.33	3.97	5.97	7.95	3.97	3.97	5.97	5.97	8.64	8.64	5.88
	C_{21}	0.34	0.09	10	0.00	2.00	4.00	6.00	6.00	4.00	4.00	6.00	6.00	8.00	8.00	0.00
	C_{22}	0.34	0.08	10	0.00	0.00	2.00	4.00	8.00	2.00	2.00	4.00	4.00	8.00	8.00	8.00
	C_{23}	0.32	0.08	10	2.00	2.00	6.00	8.00	10.00	6.00	6.00	8.00	8.00	10.00	10.00	10.00
C_3		0.25			0.00	0.00	0.00	0.00	0.00	8.74	7.78	8.74	7.78	8.74	7.78	7.78
	C_{31}	0.37	0.09	10	0.00	0.00	0.00	0.00	0.00	10.00	4.00	10.00	4.00	10.00	4.00	4.00
	C_{32}	0.33	0.08	10	0.00	0.00	0.00	0.00	0.00	8.00	10.00	8.00	10.00	8.00	10.00	10.00
	C_{33}	0.30	0.07	10	0.00	0.00	0.00	0.00	0.00	8.00	10.00	8.00	10.00	8.00	10.00	10.00
C_4		0.25			0.89	1.78	2.67	3.56	4.45	7.11	8.22	8.00	9.11	8.89	10.00	10.00
	C_{41}	0.45	0.11	10	2.00	4.00	6.00	8.00	10.00	6.00	6.00	8.00	8.00	10.00	10.00	10.00
	C_{42}	0.55	0.14	10	0.00	0.00	0.00	0.00	0.00	8.00	10.00	8.00	10.00	8.00	10.00	10.00
	TOTAL	5.00	1.00		0.25	0.29	0.48	0.54	0.47	0.69	0.67	0.73	0.72	0.79	0.77	0.60
	Performance Ranking				12	11	9	8	10	5	6	3	4	1	2	7

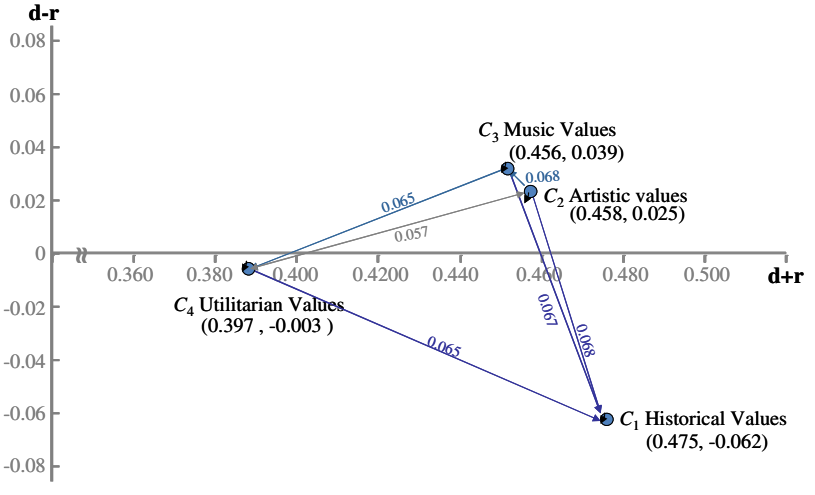

Fig. 2 The NRM of each dimension

5 Conclusions

The study described in this paper demonstrates the restoration of historical organ is within the realms of possibility. The possibilities of application of multi-criteria decision support in choosing an approach to conservation of historical organ have been presented. The work resulted in the renovation of a valuable Instrument made by Polish organ-builders. It seems that this methodology may be applied also for a wider range of objects of historical value, although this requires complex analysis of the set of criteria under consideration. Another issue requiring situation analysis would be the course of action in the case when decision alternatives/variants are evaluated by a group of experts.

This study is including different structure to be overcome. For this purpose, an idea generation method has been proposed in which the influence matrix is adopted based on many fields knowledge. Here, we employed with an innovative method with group expert's participation and multi-criteria decision making, the concept of ANP handling with many potential uncertainty factors which is able to evaluate and provide the most suitable guide for evaluating the restoration value of historical organ.

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Immunization of Networks via Modularity Based Node Representation

Tetsuya Yoshida and Yuu Yamada

Abstract. We propose an approach for immunization of networks via modularity based node representation. Immunization of networks has often been conducted by removing nodes with large centrality so that the whole network can be fragmented into smaller subgraphs. Since contamination is propagated among subgraphs (communities) along links in a network, besides centrality, utilization of community structure seems effective for immunization. However, despite various efforts, it is still difficult to identify true community labels in a network. Toward effective immunization of networks, we propose to remove nodes between communities *without* identifying community labels of nodes. By exploiting the vector representation of nodes based on the modularity matrix of a network, we propose to utilize not only the norm of vectors, but also the relation among vectors. Two heuristic scoring functions are proposed based on the inner products of vector representation and their filtering in terms of vector angle. Preliminary experiments are conducted over synthetic networks and real-world networks, and compared with other centrality based immunization strategies.

1 Introduction

Various resources are connected to each other and form networks, including the Internet, human networks such as social networks [5]. Links among resources makes it easier to exploit other resources by overcoming geographical or temporal distance. However, fast spreading of information over networks can have negative aspects, such as computer viruses or epidemics of diseases.

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The spread of epidemics (e.g., virus) can occur through the interaction between nodes in a network. Removing contaminated nodes (or, vaccinating nodes) can prevent the spread of epidemics over the whole network. However, usually the amount of available doze is much smaller than the total number of nodes. Thus, it is important to selectively utilize the available doze for removing nodes from a network for the immunization of networks.

Since contamination is propagated among subgraphs (communities) along links in a networks, the standard approach is to immunize nodes which play the major role in propagation. Based on the assumption that such nodes are in some sense "central" nodes in networks, various heuristic immunization strategies have been proposed based on the notion of node centrality [7]. In addition, by assuming that community labels of nodes are available, an immunization strategy which utilizes the community labels was also proposed [4] based on a perturbation approach [10]. However, despite various efforts, it is still difficult to identify true community labels from networks [2, 7].

Toward effective immunization of networks, we propose to remove nodes between communities *without* identifying community labels of nodes. By exploiting the vector representation of nodes based on the modularity matrix of a network [6, 11], we propose to utilize not only the norm of vectors, but also the relation among vectors. Two heuristic scoring functions are proposed based on the inner products of vector representation and their filtering in terms of vector angle. Preliminary experiments are conducted over synthetic networks and real-world networks. Comparison with other centrality based immunization strategies shows that the proposed approach is promising.

2 Immunization of Networks

2.1 Preliminaries

We use a bold italic lowercase letter to denote a vector, and a bold normal uppercase letter to denote a matrix. $\mathbf{X}_{ij}$ stands for the element in a matrix $\mathbf{X}$, and $\mathbf{X}^T$ stands for the transposition of $\mathbf{X}$. $\mathbf{1}_n \in \mathbb{R}^n$ stands for a column vector where each element is 1.

Let n stands for the number of nodes in a network G, and m stands for the number of links in G [1]. Since most social networks are represented as undirected graph without self-loops [5], we focus on this type of networks in this paper.

The connectivity of a network is usually represented as a square matrix $\mathbf{A} \in \{0,1\}^{n \times n}$ which is called an adjacency matrix. $\mathbf{A}_{ij} = 1$ when the pair of vertices (v_i, v_j) is connected; otherwise, 0. For an undirected graph without self-loops, the corresponding adjacency matrix $\mathbf{A}$ is symmetric and its diagonal elements are set to 0. The vector $\boldsymbol{k} = \mathbf{A}\mathbf{1}_n$ denotes the degree vector, where k_i represents the degree (number of links) of i-th node in a network.

[1] We also call a network as a graph, a node as a vertex, and a link as an edge.

2.2 Immunization Strategies Based on Centrality

Various kinds of "node centrality" have been studied and utilized in order to identify important nodes in social network analysis [5, 7]. A node with large centrality plays an important role in a network in some sense. Thus, removing such node has been widely used as a heuristic immunization strategy.

Since nodes with many links can be considered as a hub in a network, the degree (number of links) of a node is called degree centrality. On the other hand, betweenness centrality focuses on the shortest path along which information is propagated over a network. By enumerating the shortest paths between each pair of nodes, betweenness centrality of a node is defined as the number of shortest paths which go through the node.

Similar to the famous Page Rank, eigenvector centrality utilizes the leading eigenvector of the adjacency matrix $\mathbf{A}$ of a network, and each element (value) of the eigenvector is considered as the score of the corresponding node. Based on the approximate calculation of eigenvector centrality via perturbation analysis, another centrality (called dynamical importance) was also proposed in [10]. By assuming that community labels of nodes in a network can be specified, perturbation analysis is utilized for approximately calculating the leading eigenvector among communities in [4].

2.3 Modularity of Networks

Besides immunization, community discovery from networks has also been studied [5, 7]. Modularity has been widely utilized as a quality measure of communities based on the identified community labels in a network [6]. Under the so-called *null model*, modularity Q of a network G is defined as:

$$Q = \frac{1}{2m} \sum_{C \in \mathcal{P}} \sum_{i,j \in C} (\mathbf{A} - \mathbf{P})_{ij} \tag{1}$$

where $\mathbf{P} = \boldsymbol{k}\boldsymbol{k}^T/2m$, $\boldsymbol{k}$ is the degree vector of G. $\mathcal{P}$ stands for the partition of G, and C runs over the communities in $\mathcal{P}$. Communities with larger modularity are considered as better partitioning of nodes in a network.

3 Immunization of Networks via Modularity Based Node Representation

3.1 Community Centrality Based on Modularity

For community discovery, it is shown that maximization of modularity in eq.(1) can be sought by finding the leading eigenvector of the following matrix, which is called a modularity matrix [6]:

$$\mathbf{B} = \mathbf{A} - \mathbf{P} \tag{2}$$

By utilizing several eigenvectors of $\mathbf{B}$ in eq.(2) with the largest positive eigenvalues, the modularity matrix $\mathbf{B}$ can be approximately decomposed as:

$$\mathbf{B} \simeq \mathbf{U}\mathbf{\Lambda}\mathbf{U}^T \tag{3}$$

where $\mathbf{U}=[\boldsymbol{u}_1, \cdots, \boldsymbol{u}_q]$ are the eigenvectors of $\mathbf{B}$ with the descending order of eigenvalues, and Λ is the diagonal matrix with the corresponding eigenvalues.

A new node score called community centrality was proposed in [6] based on the above approximated decomposition. First, a new data representation (data matrix) $\mathbf{X}$ was proposed based on eq.(3) as:

$$\mathbf{X} = \mathbf{U}\mathbf{\Lambda}^{1/2} \tag{4}$$

Each row of $\mathbf{X}$ corresponds to the representation of a node. Hereafter, the i-th node in a network is represented as a column vector $\boldsymbol{x}_i$ based on eq.(4). With this vector representation, community centrality (CC) was defined as [6] [2]:

$$CC(\boldsymbol{x}_i) = \boldsymbol{x}_i^T \boldsymbol{x}_i \tag{5}$$

3.2 Community Boundary Nodes Based on Modularity

As in the heuristic strategies in Section 2.2, removing nodes with large community centrality seems a reasonable immunization strategy. However, a node with large community centrality would be around the "center" of a community by definition. Thus, although a node with larger community centrality would be connected to other nodes in the same community, since it would not be connected to nodes in other communities, it might not be so effective to fragment communities in a network.

Instead of identifying and removing central nodes in communities, we propose to remove nodes which reside between communities. If the community label of each node in a network can be identified, it would be possible to estimate community centers as well as nodes between communities. However, although various methods have been proposed for community discovery from networks [9, 8, 6, 7, 11], it is still difficult to identify the true community labels. Besides, it is proved that finding the communities with maximum modularity for a network is NP-complete [2].

Toward effective immunization of networks, we try to identify and remove nodes between communities *without* estimating or utilizing community labels of nodes based on the vector representation in eq.(4) from the modularity matrix.

[2] Both the square sum ($\boldsymbol{x}_i^T \boldsymbol{x}_i$) and the absolute sum (norm) ($||\boldsymbol{x}_i||$) were called community centrality in [6].

3.3 A Hyper-Plane Based Filtering Approach

Although we cannot utilize community labels of nodes, whether a node reside between communities still depends on the relation among nodes in a network. The notion of community centrality in eq.(5) only utilizes the norm (or, square norm) of the vector representation $\boldsymbol{x}_i$ for each node in eq.(4). In order to identify nodes between communities, we propose to utilize the relation among nodes in a network as well.

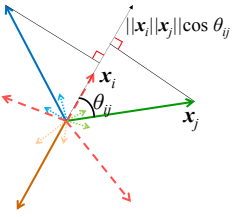

Fig. 1 Modularity based representation

For each node representation $\boldsymbol{x}_i$, we consider the contribution from another nodes $\boldsymbol{x}_j, j \neq i$, and quantify the contribution as the inner product $\boldsymbol{x}_i^T\boldsymbol{x}_j$. The inner product represents to what extent other node $\boldsymbol{x}_j$ contributes to the direction $\boldsymbol{x}_i$ (see Fig. 1). Note that $\theta_{ij} = \cos^{-1}\frac{\boldsymbol{x}_i^T\boldsymbol{x}_j}{||\boldsymbol{x}_i||||\boldsymbol{x}_j||}$ represents the angle between vectors $\boldsymbol{x}_i$ and $\boldsymbol{x}_j$.

We categorize nodes in a network into the following three types:

i) nodes around the center of a community
ii) nodes in the fringe of a community
iii) nodes between communities

If a node $\boldsymbol{x}_i$ is in **i)**, it would be "far away" from other node $\boldsymbol{x}_j$ in different communities in terms their angle θ_{ij}. Thus, $\boldsymbol{x}_i^T\boldsymbol{x}_j$ would be small for most nodes unless $\boldsymbol{x}_j$ is in the same community. On the other hand , if a node $\boldsymbol{x}_i$ is in **ii)**, by definition of community centrality, its norm $||\boldsymbol{x}_i||$ would be small. Thus, $\boldsymbol{x}_i^T\boldsymbol{x}_j$ would be small. Finally, if a node $\boldsymbol{x}_i$ is in **iii)**, its norm $||\boldsymbol{x}_i||$ would not be too small, and $\boldsymbol{x}_i^T\boldsymbol{x}_j$ can be counted from nodes in different communities.

Based on the above argument, for each node $\boldsymbol{x}_i$, we consider the contribution from another nodes $\boldsymbol{x}_j$ as $\boldsymbol{x}_i^T\boldsymbol{x}_j$, and sum up the contributions. However, simple sum over all nodes cannot be utilized from the following observation [6].

Observation 1. *For an undirected network with n nodes, for each node i in the network, $\sum_{j=1}^n \boldsymbol{x}_i^T\boldsymbol{x}_j = 0$.*

Proof. By the definition of $\mathbf{P}$ in eq.(1), for an undirected network G with n nodes, $\mathbf{1}_n$ is the eigenvector of $\mathbf{B}$ with eigenvector 0. Since we select several eigenvectors with the largest positive eigenvalues to construct $\mathbf{X}$ in eq.(4), all the column vectors of $\mathbf{U}$ are orthogonal to $\mathbf{1}_n$. Thus, since $\mathbf{1}_n^T\mathbf{X} = \mathbf{0}_q^T$ holds, $\sum_{j=1}^n \boldsymbol{x}_i^T\boldsymbol{x}_j = \boldsymbol{x}_i^T(\sum_{j=1}^n \boldsymbol{x}_j) = \boldsymbol{x}_i^T(\mathbf{1}_n^T\mathbf{X})^T = \boldsymbol{x}_i^T\mathbf{0}_q = 0$. □

From the above observation, instead of *all* the nodes, it is necessary to selectively consider the contribution from other nodes. Since the inner product represents the contribution of other node $\boldsymbol{x}_j$ to the direction of $\boldsymbol{x}_i$, if $\boldsymbol{x}_i^T\boldsymbol{x}_j < 0$, $\boldsymbol{x}_j$ does not contribute to $\boldsymbol{x}_i$. Thus, we propose the following node score:

$$hpf(\boldsymbol{x}_i) = \sum_{j:\ \boldsymbol{x}_i^T \boldsymbol{x}_j \geq 0} \boldsymbol{x}_i^T \boldsymbol{x}_j \tag{6}$$

In eq.(6), only nodes with non-negative contributions are summed up. As shown in Fig. 2, when we consider a bisecting hyper-plane perpendicular to $\boldsymbol{x}_i$, contributions from nodes in the same side with $\boldsymbol{x}_i$ are considered in eq.(6). Thus, we name the node score in eq.(6) as Hyper-Plane based Filtering (hpf).

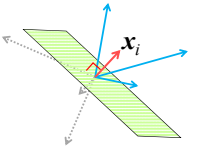

Fig. 2 Hyper-plane based filtering

3.4 A Conic Filtering Approach

For each node i, the score in Section 3.3 filters out contributions from the nodes in the opposite side of the hyper-plane. However, since the score is based on the inner product, a node with large norm ($||\boldsymbol{x}_i||$) tends to have larger score in eq.(6). Thus, in addition to the nodes between communities, nodes around the center of a community also tend to have larger score in eq.(6).

Community centrality in eq.(5) only considers the norm of each vector *separately*. In addition to the norm of vectors, we propose to exploit the relation among vectors in order to identify nodes between communities. Note that θ_{ij} represents the angle between vectors $\boldsymbol{x}_i$ and $\boldsymbol{x}_j$. Especially, $\cos\theta_{ij}$ has been widely utilized as cosine similarity in text analysis.

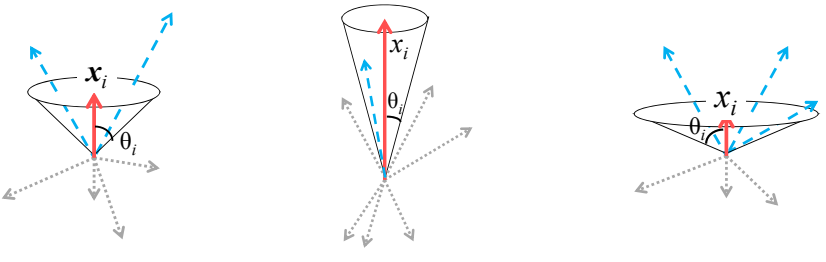

Fig. 3 Conic-filtering

Based on the above argument, we propose another filtering based scoring funciton based on a cone around each node. For the modularity matrix of a network, suppose we use q eigenvectors with positive eigenvalues in eq.(3) [3]. As illustrated in Fig. 3, for each node $\boldsymbol{x}_i$, we consider a (hyper-) cone around $\boldsymbol{x}_i$ in $\mathbb{R}^q$. The tip of the cone is the origin of $\mathbb{R}^q$, the height is $h_i = ||\boldsymbol{x}_i||$, and the conical angle θ_i (see Fig. 3). By considering a (hyper-) cone for each node $\boldsymbol{x}_i$, we filter out the nodes with which the angle exceeds θ_i for each node i.

[3] We assume $q > 1$, since we consider vector representation of nodes.

The conical angle θ_i for each node controls to what extent other nodes are filtered out. When vectors are randomly distributed around the origin in $\mathbb{R}^q$, the number of vectors (nodes) inside a cone would be proportional to the volume of the cone. By exploiting the property of vector representation in eq.(4), we set the conical angle θ_i so that the volume of the cone is invariant to all the nodes. To realize this, for each node, we set the conical angle θ_i as:

$$\theta_i = \arctan(\frac{c}{h_i^q})^{1/(q-1)} \tag{7}$$

where $h_i = ||\boldsymbol{x}_i||$, and c is some positive constant.

With the above conical angle θ_i, the following property holds:

Property 1. When the conical angle θ_i is set as eq.(7) for each node, the volume of the cone is invariant to all the nodes.

Proof. Since each cone is in $\mathbb{R}^q$, its volume V_i is proportional to the product of its height h_i $(=||\boldsymbol{x}_i||)$ and the volume of its base. Since the base of a cone in $\mathbb{R}^q$ forms a $q-1$ dimensional hyper-sphere, by denoting its radius as r_i, the volume of the base is proportional to r_i^q, i.e., $r_i \propto r_i^q$. Furthermore, with the conical angle θ_i and h_i, we can represent r_i as $r_i = h_i \tan\theta_i$. Thus, the volume of the cone $\propto h_i^q(\tan\theta_i)^{q-1}$. By setting $h_i^q(\tan\theta_i)^{q-1} = c$ for some constant c, we obtain eq.(7). □

For instance, for a node with large norm (i.e., around a community center), its conical angle gets smaller (middle figure in Fig. 3). On the other hand, for a node with small norm (i.e., in the fringe of a community), its conical angle gets larger (right figure in Fig. 3).

The above idea is formalized as the following node scoring function, which is called a Conic Filtering (cf):

$$cf(\boldsymbol{x}_i) = \sum_{j:\ \theta_{ij} \le \theta_i} \boldsymbol{x}_i^T \boldsymbol{x}_j \quad \textit{with } \theta_i \textit{ in eq.(7)} \tag{8}$$

The constant c in eq.(7) is a parameter, and we set as c=1 in the experiments.

4 Preliminary Evaluations

4.1 Experimental Settings

Datasets. Preliminary evaluations were conducted over both synthetic networks and real-world networks. Utilized networks are shown in Table 1 and Table 2.

As synthetic networks, an *ad hoc* random network ER in Table 1 was generated using Erdös-Rény (ER) model [3]. The link probability was set to

Table 1 Synthetic Networks

dataset	# nodes	#links (ave)
ER	500	1929.7
BA	500	1946.3

Table 2 Real-World Social Networks

dataset	#nodes	#links
dolphins	62	159
polbooks	115	613
netscience *	379	914
IV'04 *	112	255

0.0155. The scale-free network BA in Table 1 was generated using Barabási-Albert (BA) model [1] by setting the degree distribution $p(k) \propto k^{-3}$, where k denotes the degree of a node. The initial degree was set to 4. Since these are random networks, we constructed 10 networks for each type and report the average result.

The first three real-world networks in Table 2 are available as GML (graph markup language) format[4]. The last network (IV'04) is a co-authorship networks among researchers[5]. Since the third and fourth networks (netscience* and IV'04*) are disconnected, we conducted experiments on the maximum connected component in these networks.

Quality Measures. By following the quality measure in [4], the relative size S of the largest connected component (LCC) in a network was measured against the node occupation probability p. After removing some nodes from a network with n nodes, these are calculated as:

$$S = \frac{\#nodes\ in\ LCC}{n}, \quad p = \frac{\#remaining\ nodes}{n} \tag{9}$$

The smaller S is, the better a immunization strategy of networks is, since it can prevent the spreading of contamination over the whole network.

Compared Methods. For comparison, immunization strategies based on node centrality in Section 2.2 and Section 3.1 were evaluated. The node with the maximum centrality was repeatedly selected and removed in each strategy:

D : degree centrality (gray line with "x" in Fig. 4 and Fig. 5)
B : betweenness centrality (black line with "+")
RB : repeated calculation of betweenness centrality (black dotted line)
EVC : eigenvector centrality (yellow line with square)
CC : community centrality (blue line with upper triangle)

The proposed methods are shown with lower triangle (hpf (green line) and cf (red line) in Fig. 4 and Fig. 5).

Except for RB, node centrality was calculated only once with respect to the whole network (including our proposals). On the other hand, since betweenness centrality (B) is known to be effective (but with huge computational

[4] http://www-personal.umich.edu/~mejn/netdata/
[5] http://iv.slis.indiana.edu/ref/iv04contest/