# AHP IN CHINA

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## ABSTRACT

In this paper, the recent development of AHP in China last year. is reviewed. Our summary emphasizes the theoretical and methodological aspects of the development.

## I. INTRODUCTION

Last year, AHP was widespread both in the aspects of theory and applications in China. More than 200 papers were published in various magazines, proceedings and report.In the First Conference on the AHP, held on August 31--September 3, 1987, in Tianjin, about one hundred people attended presenting 53 papers. Being invited to the Conference, R. Manabe gave his plenary lecture entitled "Using the AHP to overcome the difficulties in the applications of OR--the applications of AHP in Japan". The Chinese Special Interest Group in the AHP, headed by B. Liu, were set up at the Conference in order to organize the activities of education, training and study on the AHP in China.

The founding book by T. L. Saaty--The Analytic Hierarchy Process was translated into Chinese by S. Xu and others and published by the Coal Mine Industry Press. Tianjin University Press published S. Xu's book "The Principle of the AHP" which is considered as a comprehensive discussion on the theory of the AHP. Xu, under supervision of B. Liu, received his Ph.D. degree with dissertation "The Basic Principles, Some Mathematical Foundation and Methodologies of the AHP".

The International Symposium on the Analytic Hierarchy Process (ISAHP) is paid a great attention and is considered as an important academic activity in the Chinses OR and systmes engineering circles. 135 papers concerning the theory, methodological researches and applications of the AHP are presented.

A research program on "Neural Transmission and Generalization of the AHP to the Continuous Case", supported by National Natural Science Foundation of China, has begun in Institute of Systems Engineering, Tianjin University.

In this paper, we overview the recent development of the AHP, especially in the aspect of its theory. The reviews can be divided into three sections: theory and methodology;applications;

software research. Most of references of this paper can be found in the Preprints of ISAHP.

## II. Theory and Methodology

### The Principle of the AHP

In his dissertation [1], S. Xu considers that the AHP is a method of measurement for socia-economic systems. He discusses the idea of the topological group of posistive reciprocal matrices and gives the mathematical structure of the group. Using the concept and methods of the topological group, he proves the necessary and sufficient conditions of characterizing principal left-right eigenvectors reciprocity in a positive reciprocal matrix.

Huang Xuli [2] provides a general principle of rank preservation when a new group of elements are added. He begins with a basic concept of cross comparison matrix then the necessary and sufficient conditions for rank preservation are presented and proven. In addition, he discusses an extended result about the cross comparison matrix.

From the point of view of multiobjective decision making, Wei Shixiao and Huang Jing [3] divide the hierarchic structure into two parts. One is the hierarchy order combined with weight w from total objective level to the last but one level, which is regarded as the decision maker's preference to each criterion. Another is the hierarchy order odd weight matrix from the last level to the criterion level, which is regarded as the decision making matrix of multiple attribution decision making (MADM) problem or the optimal membership degree of fuzzy multiple attribution decision making problem. The authors discuss the completeness and optimal conditions of the algorithm applying AHP in MADM or Fuzzy MADM (FMADM).

### The Hierarchy Structure and the Structure of Systems with Feedback

The theory and methodology of systems with feedback are paid a great attention owing to their applications to the analysis of industry structure of China. Liu Lin et al. [4] discuss the simplification of the computing formulae of limit absolute priority (LAP) and limit impact priority (LIP). In terms of the definitions of mean limit impact priority and mean limit absolute priority, they provide a computing formulae of these priorities.

Xu Lifeng [5] introduces (0-1)-matrix to express the structure of a general system, either a simple hierarchy or network with feedback. Basing on the theory of Boolean matrix, he discusses some graphical expressions of the structural characteristics such as reducibility, primitivity, periodicity and their impact upon the convergence of the structure matrix. The author provides a general method as well as a basic process for discrimination of the structural types of a system according to the structural

digraph.

Wang Hui et al. [6], Guo Fan et al. [7] both deal with the hierarchic structure with inner dependency. Wang et al. provide a new method for calculating the priority of hierarchic system with inner dependence based on the principle of hierarchic composition which is different from Saaty's supermatrix method and is an improvement of the ratio scale approach. Guo et al. give a simplified formula of calculation of compositive priority about hierarchic structure with inner dependence. Guo's method is applied to solve the indexes weighting of the evaluation model of the key products in Tianjin.

The Scale

J. Zuo [8] presents concepts and approaches of the judgments of the ordinal pairwise comparisions and the judgment of the cardinal pairwise comparison.By these concepts and approaches the decision makers can easily apply the AHP to practices. He gives applications and comparative analysis which show that the improvement of the AHP is simple and the appoach is easy in use, reliable and good in consistency.

Shu Kang and Liang Zhenhan provide with an exponential scale mehtod with "equidistant grading and equiratio valuation" in their paper [9]. The scale bases on the AHP ordering principle and eliminates the inconsistency of the pairwise comparison which results from "1-9" scale. The scale makes the consistency of pairwise comparisons equivalent to the consistency of judgment thinking, and the ordering weights have definite sense. Shu and Liang give a procedure for computing and adjusting the ordering weights in order to make them more simple and convenient.

The Pairwise Comparison Matrix

Chen Baoqian, Liu Guiru and Chai Qiaozhu [10] discuss the issue of the revision of the pairwise comparison matrix. For the eigenvector priority, some elements of a pairwise comparison matrix would be revised if the principal eigenvalue of the matrix is too great. When one pair comparison are revised, they show that which elements in the matrix, and how are revised will lead a descent of the principal eigenvalue. An iterative procedure for the repeated revision is given and the convergence of the procedure is proven in their paper.

For examining consistency of pairwise comparison matrix in the AHP, Wu Wenjiang [11] gives a method by means of which values of characteristic polynomial and its derivative can be found without solving maximum eigenvalue of the matrix.

Group AHP and Fuzzy AHP

Wang Ruhua, Li Guangquan and Xu Shubo [12] discuss the method of synthesizing judgments in the AHP in group decision making (GAHP). Several criteria and conditions are developed from

statistical considerations. Based on the criteria and conditions, they give a method for distinguishing and determining divergent individuals. The method can be described by the following step:

Step 1. Checking all indivdual judgments to see whether there is any abnormal judgments.

Step 2. Checking individuals to see whether there is any abnomal individual, the abnormal individuals will not be allowes to the final group decision step.

Step 3. Checking the divergence of the group. After kicking out the abnormal judgement and individuals, the synthesized judgement showed be tested to see whether they are divergent, only convergent judgment canbeused.

Xu Ruoning and Zhai Xiaoyan [13] present the method of group decision when the fuzziness of judgment in pairwise comparison of alternatives are applied. In the method the fuzzy judgment matrix is given as set-valued statistics method on continuous judgment scale. They prove that every element of the fuzzy judgment matrix can be represented by positive bounded closed fuzzy number. The properties of positive bounded closed fuzzy number are discussed and the fuzzy weight vector of alternatives is introduced by applied fuzzy extension principle to the altered gradient eigenvector method in their paper.

Meng Xianchang et al. [14] present a Group Decision Making Fuzzy AHP Model (GFAHP) to analyze inviting tenders process. In their model, an objective consistency index (OCI) is introduced. By the OCI pairwise comparison matrix is converted into a particular linear goal programming model in which testing consistency and checking, correcting abnormal entries, and finding out relative importance weights of elements are implemented simultaneously.

When fuzzy information are applied to give the pairwise comparisons, the AHP is considered as Fuzzy-AHP. In this case R-fuzzy sets are introduced instead of exact ratio of pairwise comparisons. In order to reduce the working amout if calculation, Hu Zhaoguang [15] defines the new concepts and operators. He summarizes the multiple expert's judges in the R-fuzzy sets. The R-fuzzy sets can be easily used in practice.

## III. APPLICATIONS

The AHP has been recognized in China and elsewhere as a powerful tool in planning, decision making, forecasting and systems analysis. In the last year, many agencies of Chinese governments, as Labour Ministry, Energy Ministry and so on, have used the AHP in planning, technology development and strategy and police analysis.

Applications of the AHP concern with 15 fields in the last year in China. They are: analysis of reasonable industry structure, education, planning of science and technology, examination and evaluation of cadres, Strategy planning of physical education,

synthetic evaluation of scientific research outcomes, medical and health work, environment protection, transportation and traffic systems, land use, rural economic developing strategy, resource allocation, product performance evaluation, accouting audit and evaluation of bidders. The reader interested in applications of AHP in China can refer to the preprints of the ISAHP.

## IV. AHP SOFTWARE

Many softwares based on AHP have been developed and applied in China. DECISION MAKER (DM), developed by Chen, S. C., Pu, E. F. and Zhou, Z. Y. [16] is the first software system in Chinese. It is designed for IBM PC with a wide range of applications. Main features of the DM are: (1) editing hierarchical structures, (2) printing-out the structures and their relevent data, (3) computing local and global weight with consistency check, (4) interface to database, and (5) sensibility check. Two kinds of programs by their uses are identified as follows: one is educational and practical, another is managerial, administrative and scientific. The DM is a software developed for both educational and practical purpose. It is able to handle large scale matrices, especially to select the best from over one hundred alternatives that is sometimes necessary for the decision making in the real world. Not only can the DM do qualitative analysis, it can also achieve exact numerical analysis. From this point of view, it is a software for decision-making in administrative, managerial as well as scientific problems.

The software AHP-NK, developed by Li Shubing and Chen Baoqian, [17] provides a practical tool of using the AHP for user. For a single criterion priority, three following mehtods can be used in the AHP-NK: The right eigenvector, the least square, and least deviation. The output results of the AHP-NK include adjacency matrices, pairwise comparison matrices, local priority vectors, consistency indexes and global composite priority vectors ( or impact priority vectors ) of a structure model. If the consistency of the pairwise comparison matrix is not satisfied, output can give a suggested revision matrix.

Some softwares applying AHP to special purposes have developed in China. Sun Hongcai et al. [18] has designed a multi-functioned software in the checking and evaluating officers. Using the software, the results of checking and evaluating can be marked by Chinese characters and shown in drawing, copy, and typewriting. The image is so audio-visual that it is easily analyzed, such as the showing of the rectangular drawing of the printed branch target of cadres' hierarchy curve, the rectangular drawing of total scores. The software is popular and easy to use. It may revise the target system, hierarchy constructure, relative weighting and the contents of word storage.

Zheng Min et al. [19] develops a software for synthetic evaluation of scientific research outcomes. Through data processing, the software can list the classified priorities of

four-type researches and the priorities of all researches in order to analyze quantitatively the evaluation quality of evaluating staff.

## V. Conclusion

Many researchers in the fields of operations research and systems engineering in China are interested in developing the theory, methodology, applications and software systems of the AHP. Some institutes and organizations have begun the AHP researches program.

In the coming years, the AHP will become a factor in the thinking of the Chinese people, and further rapid development of the AHP both in its research and applications will become apparent.

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