An Application of AHP to a Techno-economic Evaluation of Automation Control System

Zhenhuan Sun   and   Fengshan Zhang
Tianjin Institute of Light Industry , Tianjin 300222, P. R. CHINA

Abstract: In this paper the A H P is used to techno-economically evaluate automation control system of industorial procesess.Having analysed a lot of automation control system throughly, a multi-level hierarchical structure model for it is set up. A H P is then employed to determine the weights of appraisal indices. Thus, experts' judgements can be combined to produce better evaluations.

Using a microcomputre, some scientific evaluation conclusion are made,based on the synthesises,comparison and statisticals calculations.The real examples are carried out with satisfactory result.

key words: Analytic Hierarchy Process ; Automation control system ; Techno-economic evaluation

Introduction

The techno-economic evaluation of automation control system is a new subject for research that follows progress of automatic control engineering, The automation of industrial production process develops rapidly and comes up to advanced level in recent years. Thousands of new automation control systems based on the computer go into operation every year in China. Under these circumstances, the task confronting system engineers is how to make the techno-economic evaluation of automation control system and how to assure fair and equitable valuation. The researches on this task are important for impetus to progress of automatic control technology. It will provide us with the useful Decision Support System (DSS) that is used for planning, examining and approving the major research projects of automation control system as well as for appraising achievement in scientific research and deciding on awards. The D S S is also used for selecting and accepting the import technology and equipment.

Due to the sophisticated automation control system can be regarded as a complex syseten that consists of a lot of factors, some of these factors can be evaluated by quantitative assessments and others by qualitative analysis only, so the first of all is to select a scientific evaluation method. Our research is based on the Analytic Hierarchy Process(A H P), which is efficacious for multiobjective decision-making.

Techno-economic evaluation of an automation control system are carried out in the following way:
- Set up a multi-level hierarchical structure model
- A H P is employed to detemine the order of relative importance of indices
- Specialists of automation control system make individual evaluation of each index
- Using computer, some evaluation conclusions are made, based on the synthesises,comparisons and statistical calculations.

1. Multi-level hierarchical structure model

Having analised a lot of automation control systems thoroughly, a multi-level hierarchical structure model for it is set up and a set of appraisal indices is proposed.

Typical evaluation model for industrial production process control system based on the computer is shown in figure 1.
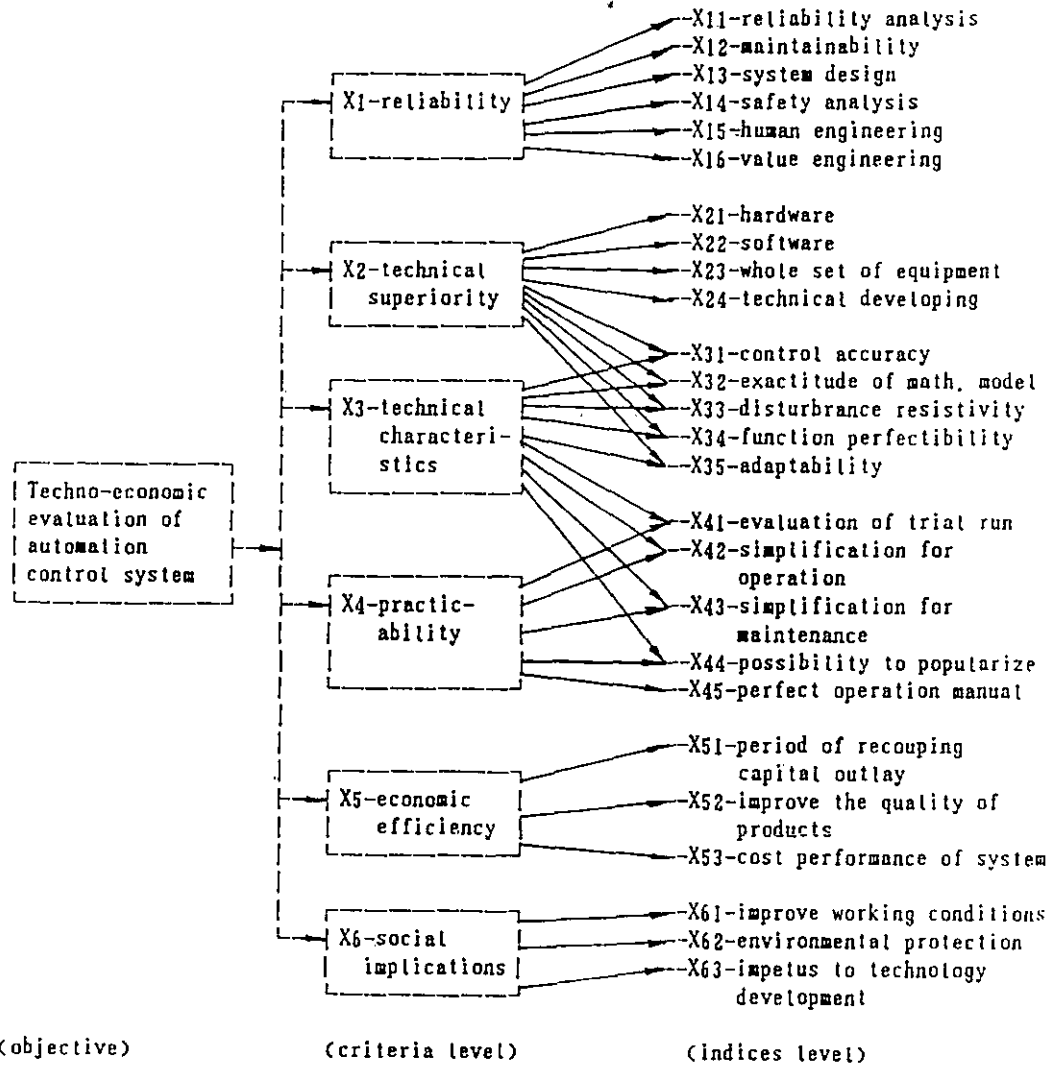

(objective)   (criteria level)   (indices level)

Fig. 1   Multi-level hierarchical structure model

2.Priority of group comparison matrices

From a group of comparison matrices given by more than thirty of experts in autocontrol engineering, the priority of guoup comparison is determined and the weights of each index are calculated. Because of the differences of the comparison qualities given individually by experts, all of relative data will be subjected to statistical processing. Thus, the weight of all indices are calaulated, for instance, typical weight of criteria to general objective are listed in table 1

table 1. typical weight of criteria to general objective

Criteria	weight
X1-reliability	0.330
X2-technical superiority	0.202
X3-technical characteristics	0.234
X4-practicability	0.088
X5-economic efficiency	0.096
X6-social implications	0.050

3.Evaluation result

Using a microcomputre and database technique, some scientific evaluation conclusion are made, based on the synthesises, analysises, comparisons and statistical calculations.

From the marks, Vij, given by experts for each index listed in indices level, the evaluation value of every criterion, Vi, is calculated as follows,

$$V_i = \sum_{j=1}^{m} W_{ij} \cdot V_{ij}$$

where $i = 1, 2, \cdots 6$; $j = 1, 2, \cdots m$

$m = 1, 2, \cdots$, the mumber of indices related with criterion Xi

Wij — weights of indices to relative criterion

General evaluation value of the system, V, is calculated as follows,

$$V = \sum_{i=1}^{6} \sum_{j=1}^{m} W_j \cdot W_{ij} \cdot V_{ij}$$

where Wi--weights of criteria, "i" to general objective

In the calculation of evaluation, all data will be subjected to statistical processing either, so as to reduce the man-made effect.

4.Application

This evaluation method was used successfully to evaluate two big automation control system based on minicomputer, ---- a Hierarchical Control System for production process of chemical feritizer and a H C C system for production process of soda ash. The real examples are carried out with satisfactory results.

5. Summing up

Our method has following features,

(1) Based on scientific theory A H P which is generatly acknowledged as the proper method used for multiobjective decision-making

(2) Reference data are reliable. All of basic materials such as evaluation model, indices and comparison matrix are determined by consultation with large numbers of experts.

(3) The method proposed is relatively simple and easily realized.
Using a microcomputer and database technique allows us to process larger numbers of data and information rapidly and exactly.

(4) Evaluation result is fair and equitable.

In fact, the evaluation method, by means of giving mark, as a subjective method, is liable to be affected by exactitude of indivdual judgment. Because the experts who take part in evaluation are senior specialists in corresponding field, all of them know the technical data and the latest development of corresponding system, their judgments are reliable. In addition, the statistical processing of data makes the evaluation still fairer.

References
[1] T.L.Saaty, The Analytic Hierarchy Process, McGraw-Hill, New York, 1980