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The development of intelligent decision support tools to aid the design of flexible manufacturing systems

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Abstract

The design of flexible manufacturing systems (FMSs) is an essential but costly process. Although FMS design appears to be an excellent area for applying artificial intelligence (AI) and computer simulation techniques, to date there have been limited investigations on integrating AI with the modular simulation software available for FMS design. In this paper an integrated approach for the automatic design of FMS is reported, which uses simulation and multi-criteria decision-making techniques. The design process consists of the construction and testing of alternative designs using simulation methods. The selection of the most suitable design (based on the multi-criteria decision-making technique, the analytic hierarchy process (AHP)) is employed to analyze the output from the FMS simulation models. Intelligent tools (such as expert systems, fuzzy systems and neural networks), are developed for supporting the FMS design process. Active X technique is used for the actual integration of the FMS automatic design process and the intelligent decision support process.

Keywords: FMS design; Systems simulation; Multi-criteria decision support; AI; Integration

1. Introduction

Flexible manufacting system (FMS) design is a very complex task due to two important characteristics: (a) The wide variety of alternative system control strategies and configurations available to the designer [1]; (b) FMS design is a task in which a variety of selection criteria are involved, many of which are difficult to quantify. Additionally, some criteria have to be balanced against each other while taking into account the preferences of managers of the firm [2,3].

Modeling techniques have been devised to model and evaluate FMSs prior to their installation. Modeling is advantageous since it is costly to evaluate the performance of an FMS after installation. Today, physical models, analytical models, discrete simulation models, and, more recently, knowledge-based simulation systems, have been used for this purpose. However, a major problem exists as current modeling techniques are unable to capture all the FMS design dimensions, i.e. they are not able to solve the FMS design problem as a whole. This is a consequence of local, myopic, and isolated approaches to FMS design [4]. Therefore, a new approach combining operational research

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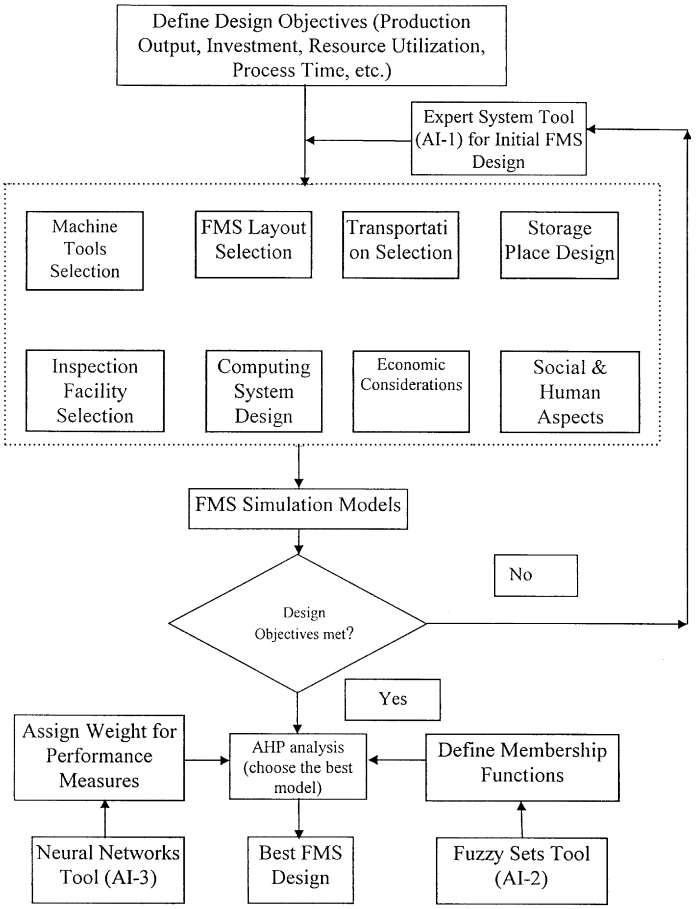

Fig. 1. Outline of the intelligent decision support system for the FMS design.

and intelligent decision-making process is needed and a user-friendly interface can be considered as being an essential requirement.

The approach introduced in this paper integrates initial FMS design, systems analysis, decision-making support and artificial intelligence (AI) techniques and methodologies into one system. Fig. 1 shows the outline of this integrative approach for FMS design. As Fig. 1 indicates, FMS design models are built based on the objectives obtained from engineers. The multi-criteria decision support technique, the analytic hierarchy process (AHP), is then used to choose the best design. AI techniques (expert system, fuzzy sets and neural network) are used for the FMS design initialization, analysis, and evaluation. In other words, the ongoing research project by the present authors tries to integrate the FMS simulation models, AI tools and the decision support system into a unified system. Thus, developing an integrative intelligent decision support system for the design of FMS is the core activity of this research.

The expert system tool (AI-1, Fig. 1) is developed to (i) analyze output from an FMS simulation model, (ii) determine whether specified design objectives are met, (iii) identify design deficiencies or opportunities for improvement and (iv) propose designs which overcome identified deficiencies or which exploit improvement opportunities. In order to establish the FMS models and AI-1, three different sources of expertise have been consulted. One source is an industrial engineering group in a Hong