Fuzzy Logic in Flexible Manufacturing System for Production Scheduling

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Abstract-

Fuzzy logic, although a mathematical technique, defines its behavioral framework through a compact linguistic rule base. It has the ability to concurrently consider multiple criteria and to model human experience in the form of simple rules. Furthermore, the advantage of the fuzzy logic system approach is that it incorporates both numerical and linguistic variables. By applying a fuzzy logic to overcome the dynamic scheduling problems in an FMS environment. The fuzzy based scheduling is designed to solve the problem of selecting the best job assignment for a given job which is the sub-problem of scheduling in a Flexible manufacturing system (FMS).

Keywords— Flexible manufacturing system, Fuzzy logic; Production scheduling, Fuzzy scheduling model**.**

INTRODUCTION

Manufacturing systems passed through different paradigms to respond to the increasing size and dynamics of the evolving market place, which is today based on heavy competitiveness. Shorter product life-cycles, unpredictable demand, and customized products have forced manufacturing system to operate more responsively to customer demand, and their ever changing requirements. Evolution of manufacturing systems has taken several forms. Job shops use general purpose machines for low volume and high variety product orders. Dedicated Manufacturing System (DMS) is driven by economy of scale for high volume and low variety products. The needs for mass customization and greater responsiveness to changes in products lead to the concept of flexible manufacturing systems (FMSs) for mid-volume, mid variety production needs [1-3].

Today's global markets are characterized by shorter product life cycle and unanticipated change in the demand. The demand change in dynamic environments, where changes to production requirements are random [4], stretch the limits of conventional manufacturing systems. To alleviate this strain on conventional manufacturing, new and innovative ways of designing manufacturing landscape have been well researched and implemented.

In the present market scenario, the customer demand and specification of any product changes very rapidly so it is very important for a manufacturing system to accommodate these changes as quickly as possible to be able to compete in the market. This evolution induces often a conflict for a manufacturing system because as the variety is increased the productivity decreases. So the flexible manufacturing system (FMS) is a good combination between variety and productivity. In this system, the main focus is on flexibility rather than the system efficiencies. A competitive FMS is expected to be flexible enough to respond to small batches of customer demand and due to the fact that the construction of any new production line is a large investment so the current production line is reconfigured to keep up with the increased frequency of new product design.

The optimal design of FMS is a critical issue and it is a complex problem. There are various modeling techniques for FMS; the most common one are based on mathematical programming. FMS is a highly integrated manufacturing system and the inter-relationships between its various components are not well understood for a very complex system. Due to this complexity, it is difficult to accurately calculate the performance measures of the FMS which leads to its design through mathematical techniques. Therefore, computer simulation is an extensively used numeric modeling technique for the analysis of highly complex flexible manufacturing systems [5]

FUZZY LOGIC

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based.

The idea of fuzzy logic was first advanced by Dr. Lotfi Zadeh of the University of California at Berkeley in the 1960s. Dr. Zadeh was working on the problem of computer understanding of natural language. Natural language (like most other activities in life and indeed the universe) is not easily translated into the absolute terms of 0 and 1. (Whether everything is ultimately describable in binary terms is a philosophical question worth pursuing, but in practice much data we might want to feed a computer is in some state in between and so, frequently, are the results of computing.) Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness."

Fuzzy logic seems closer to the way our brains work. We aggregate data and form a number of partial truths which we aggregate further into higher truths which in turn, when certain thresholds are exceeded, cause certain further results such as motor reaction. A similar kind of process is used in artificial computer neural network and expert systems.

Classical logic only permits conclusions which are either true or false. For example, the notion that 1+1=2 is a fundamental mathematical truth. However, there are also propositions with variable answers, such as one might find when asking a group of people to identify a colour. In such instances, the truth appears as the result of reasoning from inexact or partial knowledge in which the sampled answers are mapped on a spectrum.

Humans and animals often operate using fuzzy evaluations in many everyday situations. In the case where someone is tossing an object into a container from a distance, the person does not compute exact values for the object weight, density, distance, direction, container height and width, and air resistance to determine the force and angle to toss the object. Instead the person instinctively applies quick “fuzzy” estimates, based upon previous experience, to determine what output values of force, direction and vertical angle to use to make the toss.

Both degrees of truth and probabilities range between 0 and 1 and hence may seem similar at first. For example, let a 100 ml glass contain 30 ml of water. Then we may consider two concepts: empty and full. The meaning of each of them can be represented by a certain fuzzy set. Then one might define the glass as being 0.7 empty and 0.3 full. Note that the concept of emptiness would be subjective and thus would depend on the observer or designer. Another designer might, equally well, design a set membership function where the glass would be considered full for all values down to 50 ml. It is essential to realize that fuzzy logic uses degrees of truth as a mathematical model of vagueness, while probability is a mathematical model of ignorance.

APPLYING TRUTH VALUES

A basic application might characterize various sub-ranges of a continuous variable. For instance, a temperature measurement for anti-lock brakes might have several separate membership functions defining particular temperature ranges needed to control the brakes properly. Each function maps the same temperature value to a truth value in the 0 to 1 range. These truth values can then be used to determine how the brakes should be controlled.

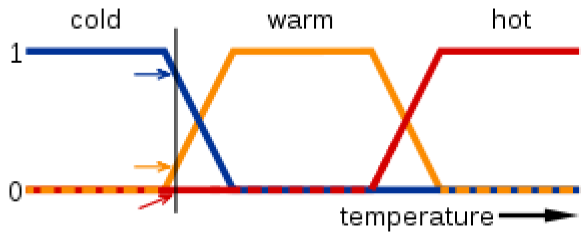

Fig.1. Fuzzy logic temperature

In this image, the meanings of the expressions *cold*, *warm*, and *hot* are represented by functions mapping a temperature scale. A point on that scale has three "truth values" — one for each of the three functions. The vertical line in the image represents a particular temperature that the three arrows (truth values) gauge. Since the red arrow points to zero, this temperature may be interpreted as "not hot". The orange arrow (pointing at 0.2) may describe it as "slightly warm" and the blue arrow (pointing at 0.8) "fairly cold".

LINGUISTIC VARIABLES

While variables in mathematics usually take numerical values, in fuzzy logic applications, the non-numeric are often used to facilitate the expression of rules and facts.[6]

A linguistic variable is *young* or its antonym *old*. However, the value of linguistic variables is that they can be modified via linguistic hedges applied to primary terms. These linguistic can be associated with certain functions.

Fuzzification operations can map mathematical input values into fuzzy membership functions. And the opposite de-fuzzifying operations can be used to map a fuzzy output membership functions into a “crisp” output value that can be then used for decision or control purposes.

METHODOLOGY

- Real-time data collection for scheduling of jobs in FMS from BEML, Mysore.
- Development of Mathematical Model using Fuzzy logic technique based on assumptions and objective function.

- Assumptions considered are all the tools are available when needed, Failure of workstations or transport systems are not subjected to failure, Pallets and fixtures are available, Routing and processing time are defined and due dates are known in advance.
- The objective function is to reduce throughput time of jobs and improve machine utilization.
- Validation of fuzzy logic results with experimental FMS setup and fuzzy logic toolbox in MATLAB software.

CONCLUSION

Optimal Fuzzy results are tabulated and compared with experimental results for criteria such as Make span, Resource Utilization, Mean Flow Time, Mean Tardiness, Mean Queue Length.

REFERENCES

The difficulty in scheduling jobs in a dynamic job shop arises as a consequence of the existence of a multicriteria objective. The relevance of the fuzzy logic approach can be justified in the desire to optimize the multiple objectives and so achieve a closer resemblance to the real-world [6]. Grabot and Geneste [7] developed aggregated rules that allow obtaining a compromise between the satisfactions of several criteria. Conbolt and Gundogar [8] introduced a new fuzzy approach using fuzzy logic to combine the priority rules such as SPT, CR and next machine load (NML) rate and named it as fuzzy priority rule (FPR). The job with highest priority value is assigned to the machine to be processed. FPR leads to significant improvement on performance measures like mean flow time, mean tardiness, WIP and throughput. Srinoi et. al [9] applied fuzzy logic in flexible manufacturing system. Four fuzzy input variables were defined. These are machine allocated processing time, machine priority, due date priority and setup time priority. The job priority is the output fuzzy variable. The model selects the machines and then assigns operation based on a multi-criteria scheduling scheme. The test result demonstrates the superiority of the fuzzy logic approach in most performance measures. Subramaniam et al. [10] proposed a fuzzy schedule that uses the prevailing conditions in the job shop to select dynamically the most appropriate dispatching rule from a set of rules. The three inputs used are relative work length (RWL), relative work remaining (RWR), and relative work remaining in next machine queue (RWN). The dispatching rules used are SPT, MWKR and WINQ. The results indicate that fuzzy scheduler performs better than common dispatching rules.

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