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One-Operation Jobs Scheduling under Fuzziness - A Review

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Abstract

Scheduling is allocation of limited resources over a time to perform tasks. Many real-time scheduling problems are both imprecise and uncertain. Fuzzy set theory has been used to model such systems. Scheduling one-operation jobs are significant. In this review the fuzziness in one-operation jobs scheduling are considered.

Keywords: Single machine scheduling, parallel machine scheduling, fuzzy set theory, review.

Introduction

In the real world, it will be more reasonable to model a problem that is concerned with both randomness and fuzziness. The concept of fuzzy sets was proposed by Zadeh [1].The impreciseness occurring in scheduling problems are categorized as fuzzy-scheduling problems. The first case study was done by Prade [2] in scheduling problems using fuzzy set theory, and a collection of articles edited by Słowin´ ski and Hapke [3] gave a main stream of fuzzy scheduling problems.

In the following sections a brief review of applications of fuzzy concepts in single machine and parallel machine scheduling problems has been discussed.

Fuzzy Applications on Single machine Scheduling problem

In a single machine scheduling problem a number of jobs (works, demands) are waiting for service on a single machine (a facility, a person) to be scheduled in the best possible manner to optimize some objective(s). Chen *et al* [4] have described a fuzzy production system for multi-objective scheduling. They have proposed a heuristic algorithm to find the optimal sequences of different single objectives as the production rules, and the fuzzy min-operator with non-linear membership function as the test criterion.

Han *et al* [5] have dealt with a generalized single machine problem with maximum lateness, fuzzy due date and controllable machine speed. They proposed a polynomial time algorithm to find an optimal schedule and optimal job wise machine speeds and to minimize the total sum of costs associated with job wise machine speeds and dissatisfaction with respect to completion times of jobs. Ishii and Tada [6] have discussed about single machine scheduling problem with fuzzy precedence relation. They considered two objectives, i.e., Lmax (maximum lateness) to be minimized, and minimal satisfaction level with respect to fuzzy precedence relation to be maximized. They have proposed an efficient algorithm to obtain the objectives.

Adamopoulos and Pappis [7] have considered a fuzzy approach to a single machine scheduling problem. The scheduling criteria are the common due date, the total earliness and tardiness and the controllable duration of the jobs' processing times. Their aim is to determine the length of the processing times, to sequence the jobs in the machine and, finally, to determine the common due date in a near optimal way. In another paper [8] they have dealt with a single machine scheduling problem with fuzzy due-dates and controllable processing times. Their objective is to maximize the “grade of satisfaction” incurred, subject to a total processing cost constraint.

Lam and Cai [9] have examined scheduling of ‘n’ jobs on a single machine. The objective of their problem was to minimize the weighted earliness and tardiness of job completions from a common due date D, where D is a fuzzy number. They have proposed a pseudo-polynomial algorithm for the objective. Adamopoulos *et al* [10] have discussed about a single machine scheduling problem where the jobs’ processing times are controllable (i.e., they may take any value within a certain range) and non-precisely defined. Their objective function is to minimise: (a) the mean flow time cost plus the mean processing cost, and (b) the maximum flow time cost plus the total processing cost. The problem is modelled as an assignment problem and is solved optimally with respect to the defuzzification strategy used.

Lam and Cai [11] have considered scheduling n jobs on a single machine. Their problem is to determine: (i) a job sequence, and (ii) a set of idle times each before one job, so as to minimize the total weighted earliness and tardiness cost under the fuzzy due dates. They have proposed a genetic algorithm for the objective. Itoh and Ishii [12] have proposed a model dealing with uncertain processing times and flexible due-dates in consideration of real situations. Assuming the times and due-dates are fuzzy numbers, and defining a fuzzy tardiness for a job’s due-date, the number of tardy jobs are minimized.

Chanas and Kasperski [13] have minimised maximum lateness in a single machine scheduling problem with fuzzy processing times and fuzzy due dates. Generalized Lawler's algorithm is used to solve the problem. Wang *et al* [14] have dealt with single machine ready time scheduling problem with fuzzy processing times. They have represented fuzzy processing time by a triangular fuzzy number. Utilizing the fuzzy extension principle and the concept of job completion likelihood profile, the ready time scheduling model that maximizes the common ready time with crisp processing times is extended to one with fuzzy processing times.

Sung and Vlach [15] have dealt with a single machine problem with a sequence of finite number of jobs with an objective of minimizing the number of jobs that are not completed by their due dates. Chanas and Kasperski [16] have discussed about two single machine scheduling problems with fuzzy processing times and fuzzy due dates. In both the fuzzy tardiness of a job in a given sequence as a fuzzy maximum of zero and the difference between the fuzzy completion time and the fuzzy due date of the job is defined. In the first problem they minimised the maximal expected value of a fuzzy tardiness and in the second problem they minimised the expected value of a maximal fuzzy tardiness.

Muthusamy *et al* [17] have considered a problem of scheduling jobs non-preemptively on a single machine subject to time delay constraints and precedence constraints. Time delay constraints and precedence constraints are fuzzified. Schedules are evaluated not only by their makespan but also by degrees of satisfaction with time delays and degrees of satisfaction with fuzzy precedence. Chanas and Kasperski [18] have considered a single machine scheduling problem with parameters given in the form of fuzzy numbers. In their paper the concepts of possible and necessary optimality of a given schedule are introduced and the degree of possible and necessary optimality of a given schedule is calculated. Jin [19] has dealt with the scheduling problems on a single machine in fuzzy random environments. He has provided three types of fuzzy random programming models for single machine scheduling with fuzzy random processing times. He has designed a hybrid intelligent algorithm to solve the proposed models.

Kasperski [20] has proposed a possibilistic approach to sequencing. His objective is to calculate a sequence of jobs, for which the possibility (necessity) of delays of jobs is minimal. Yuan and Ou [21] have analysed a single machine scheduling problem involving fuzzy time delays and fuzzy precedence constraints. They were evaluated schedules not only by degree of satisfaction with fuzzy time delays but also degrees of satisfaction with fuzzy precedence constraints. For the bi-criteria scheduling problem, they proposed an efficient algorithm for calculating non-dominated schedules. Yuan and Ou [22] have discussed about a single machine pre-emptive scheduling problem with arbitrary release dates and fuzzy due dates. Their objective was to find an optimal schedule which maximizes the minimal grade of satisfaction of jobs completion times with respect to fuzzy due dates. They proposed an $O(n^2)$ algorithm.

Li *et al* [23] have considered a single machine, due date assignment scheduling problem with uncertain processing times and general precedence constraint among the jobs. An optimal polynomial time algorithm is proposed for the problem without precedence constraints among jobs. Moghaddam *et al* [24] have developed a fuzzy multi-objective linear programming (FMOLP) model for solving a multi-objective single-machine scheduling problem. Their proposed model attempts to minimize the total weighted tardiness and makespan simultaneously.

Chengyao *et al* [25] have studied about the earliness and tardiness of scheduling problem on a single machine with fuzzy processing times. They were proposed genetic algorithms to search the near optimal solutions. Li *et al* [26] have investigated how to sequence jobs with fuzzy processing times and predict their due dates on a single machine such that the total weighted possibilistic mean value of the weighted earliness–tardiness costs is minimized. An optimal polynomial time algorithm is proposed.

Feng *et al* [27] have discussed about single machine scheduling problem with fuzzy due dates where satisfaction based benefit are relevant. They have proposed a property based on the analysis.

Fuzzy Applications on Parallel machine Scheduling problem

In a parallel machine scheduling a number of identical machines are available, and jobs can be processed on any one of them. Peng and Liu [28] have developed a methodology for modelling parallel machine scheduling problems with fuzzy processing times. They have designed a hybrid intelligent algorithm for solving these models. Anglani *et al* [29] have proposed a robust approach for solving the scheduling problem of parallel machines with sequence-dependent set-up costs. They formulated a fuzzy mathematical programming model by taking into account the uncertainty in processing times to provide the optimal solution as a trade-off between total set-up cost and robustness in demand satisfaction.

Gharehgozli *et al* [30] have presented a fuzzy mixed-integer goal programming model for a parallel-machine scheduling problem with sequence-dependent setup times and release dates. They have considered two objectives in their model to minimize the total weighted flow time and the total weighted tardiness simultaneously. Balin [31] has addressed parallel machine scheduling problems with fuzzy processing times. He proposed a robust genetic algorithm approach embedded in a simulation model to minimize the makespan. Alcan and Başlıgil [32] have proposed a genetic algorithm based on machine code for minimizing the processing times in non-identical parallel machine scheduling. They have used triangular fuzzy processing times in order to adapt the genetic algorithm.

Conclusion

In this paper a brief survey is done on fuzzy scheduling. In the above fuzzy scheduling problems various fuzzy concepts, like, fuzzy sets, triangular fuzzy sets, fuzzy logic, fuzzy numbers, fuzzy triangular numbers, fuzzy processing times, fuzzy due dates, fuzzy completion times, fuzzy integral, fuzzy relations, fuzzy measure, fuzzy product cycle times, *etc* are applied.

In the above fuzzy scheduling problems various methodologies, like, genetic algorithms, tabu search, generalized Lawler's algorithm, simulated annealing, branch and bound techniques, genetic algorithms *etc* are used.

Scheduling researches performed so far have adopted the following constraints: All the jobs are available at time zero, buffer space for work-in-process is unlimited, all problem data are deterministic, jobs having sequence-dependent setup times, equal processing times of each job in each family, common due date or common due window, jobs with distinct due dates, no insertion of idle times, no new arrival of jobs during scheduling execution. Operation pre-emption is not allowed (i.e., once processing begins on a job, it is processed to completion without interruption), each job corresponds to only one part, i.e., bill of materials are not allowed. A large variety of constraints and relaxations are to be added in order to represent as far as possible a real production environment.

A scheduling system which models the following commonly encountered characteristics would be able to solve the majority of industrial scheduling problems that arise in practice. Jobs having fuzzy distinct ready times, limited buffer space for work-in-process, stochastic job characteristics, fuzzy early and tardy costs, family of jobs with change over fuzzy setup costs, fuzzy distinct processing times of jobs in each family, allowing insertion of idle times, dynamic production environment, allowing operation pre-emption, just-in-time environment.

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