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Solving fuzzy flexible job shop scheduling problem based on fuzzy satisfaction rate and differential evolution

Ma, D.Y.[a,b], **He, C.H.**[c], **Wang, S.Q.**[d], **Han, X.M.**[b], **Shi, X.H.**[d,e,*]

[a]Business School, Jilin University, Changchun, P.R. China
[b]School of Computer Science and Engineering, Changchun University of Technology, Changchun, P.R. China
[c]School of Electronics Engineering and Computer Science, Peking University, Beijing, P.R. China
[d]Key Laboratory of Symbol Computation and Knowledge Engineering, Ministry of Education, Changchun, P.R. China
[e]College of Computer Science and Technology, Jilin University, Changchun, P.R. China

ABSTRACT

Focused on a variety of JSSP considered flexibility and fuzziness, namely the fuzzy flexibility JSSP (FfJSSP), a novel method based on fuzzy satisfaction rate and differential evolution (DE) algorithm is proposed in this paper. In the method, the fuzzy membership functions' parameters are determined according to normal distribution for maximum satisfaction rate calculation. Then a DE algorithm is proposed by well designing the coding for the problem and extending the related operators on the coding. A local exploring search for operation and machine parts of the coding is also introduced to improve the performance of the method. Experimental results show that our proposed method is effective compared with other five popular existed methods. Comparisons between different mutation and crossover strategies are also performed. Numerical results show that the proposed method could be applied to real FfJSSP problems.

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**Corresponding author:*
shixh@jlu.edu.cn
(Shi, X.H.)

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References

[1] Tang, M., Gong, D., Liu, S., Zhang, H. (2016). Applying multi-phase particle swarm optimization to solve bulk cargo port scheduling problem, *Advances in Production Engineering & Management*, Vol. 11, No. 4, 299-310, doi: 10.14743/apem2016.4.228.

[2] Burdett, R.L., Kozan, E. (2018). An integrated approach for scheduling health care activities in a hospital, *European Journal of Operational Research*, Vol. 264, No. 2, 756-773, doi: 10.1016/j.ejor.2017.06.051.

[3] Tang, M., Gong, D., Liu, S., Lu, X. (2017). Finding key factors for electric vehicle charging station location: a simulation and ANOVA approach, *International Journal of Simulation Modelling*, Vol. 16, No. 3, 541-554, doi: 10.2507/IJSIMM16(3)CO15.

[4] Wu, Z.B., Weng, M.X. (2005). Multiagent scheduling method with earliness and tardiness objectives in flexible job shops, *IEEE Transactions on Man, and Cybernetics, Part B: Cybernetics*, Vol. 35, No. 2, 293-301, doi: 10.1109/TSMCB.2004.842412.

[5] Sahin, C., Demirtas, M., Erol, R., Baykasoğlu, A., Kaplanoğlu, V. (2017). A multi-agent based approach to dynamic scheduling with flexible processing capabilities, *Journal of Intelligent Manufacturing*, Vol. 28, No. 8, 1827-1845, doi: 10.1007/s10845-015-1069-x.

[6] Zhang, Y.F., Wang, J., Liu, Y. (2017). Game theory based real-time multi-objective flexible job shop scheduling considering environmental impact, *Journal of Cleaner Production*, Vol. 167, 665-679, doi: 10.1016/j.jclepro.2017.08.068.

[7] Li, J.Q., Pan, Q.K., Tasgetiren, M.F. (2014). A discrete artificial bee colony algorithm for the multi-objective flexible job-shop scheduling problem with maintenance activities, *Applied Mathematical Modelling*, Vol. 38, No. 3, 1111-1132, doi: 10.1016/j.apm.2013.07.038.

[8] Gao, J., Sun, L.Y., Gen, M. (2008). A hybrid genetic and variable neighborhood descent algorithm for flexible job shop scheduling problems, *Computers & Operations Research*, Vol. 35, No. 9, 2892-2907, doi: 10.1016/j.cor.2007.01.001.
[9] Li, X.Y., Gao, L. (2016). An effective hybrid genetic algorithm and tabu search for flexible job shop scheduling problem, *International Journal of Production Economics*, Vol. 174, 93-110, doi: 10.1016/j.ijpe.2016.01.016.
[10] Zhang, Q., Manier, H., Manier, M.-A. (2012). A genetic algorithm with tabu search procedure for flexible job shop scheduling with transportation constraints and bounded processing times, *Computers & Operations Research*, Vol. 39, No. 7, 1713-1723, doi: 10.1016/j.cor.2011.10.007.
[11] Huang, X.W., Zhao, X.Y., Ma, X.L. (2014). An improved genetic algorithm for job-shop scheduling problem with process sequence flexibility, *International Journal of Simulation Modelling*, Vol. 13, No. 4, 510-522, doi: 10.2507/IJSIMM13(4)CO20.
[12] Gao, K.Z., Suganthan, P.N., Pan, Q.K., Chua, T.J., Cai, T.X., Chong, C.S. (2016). Discrete harmony search algorithm for flexible job shop scheduling problem with multiple objectives, *Journal of Intelligent Manufacturing*, Vol. 27, No. 2, 363-374, doi: 10.1007/s10845-014-0869-8.
[13] Li, J.Q., Pan, Q.K. (2012). Chemical-reaction optimization for flexible job-shop scheduling problems with maintenance activity, *Applied Soft Computing*, Vol. 12, No. 9, 2896-2912, doi: 10.1016/j.asoc.2012.04.012.
[14] Özgüven, C., Yavuz, Y., Özbakır, L. (2012). Mixed integer goal programming models for the flexible job-shop scheduling problems with separable and non-separable sequence dependent setup times, *Applied Mathematical Modelling*, Vol. 36, No. 2, 846-858, doi: 10.1016/j.apm.2011.07.037.
[15] Yuan, Y., Xu, H. (2013). Flexible job shop scheduling using hybrid differential evolution algorithms, *Computers & Industrial engineering*, Vol. 65, No. 2, 246-260, doi: 10.1016/j.cie.2013.02.022.
[16] Xu, Y., Wang, L., Wang, S.Y., Liu, M. (2015). An effective teaching–learning-based optimization algorithm for the flexible job-shop scheduling problem with fuzzy processing time, *Neurocomputing*, Vol. 148, 260-268, doi: 10.1016/j.neucom.2013.10.042.
[17] Supsomboon, S., Vajasuvimon, A. (2016). Simulation model for job shop production process improvement in machine parts manufacturing, *International Journal of Simulation Modelling*, Vol. 15, No. 4, 611-622, doi: 10.2507/IJSIMM15(4)3.352.
[18] Mehrabad, M.S., Pahlavani, A. (2009). A fuzzy multi-objective programming for scheduling of weighted jobs on a single machine, *The International Journal of Advanced Manufacturing Technology*, Vol. 45, No. 1-2, 122-139, doi: 10.1007/s00170-009-1947-5.
[19] Lei, D.M. (2008). Pareto archive particle swarm optimization for multi-objective fuzzy job shop scheduling problems, *The International Journal of Advanced Manufacturing Technology*, Vol. 37, No. 1-2, 157-165, doi: 10.1007/s00170-007-0945-8.
[20] Kilic, S. (2007). Scheduling a fuzzy flowshop problem with flexible due dates using ant colony optimization, In: Giacobini, M. *et al*. (eds.), *Applications of Evolutionary Computing, EvoWorkshops 2007,* Vol. 4448, Springer-Verlag, Berlin, Heidelberg, 742-751, doi: 10.1007/978-3-540-71805-5_80.
[21] Niu, Q., Jiao, B., Gu, X.S. (2008). Particle swarm optimization combined with genetic operators for job shop scheduling problem with fuzzy processing time, *Applied Mathematics and Computation*, Vol. 205, No. 1, 148-158, doi: 10.1016/j.amc.2008.05.086.
[22] Zhang, X.G., Deng, Y., Chan, F.T.S, Xu, P.D., Mahadevan, S., Hu, Y. (2013). IFSJSP: A novel methodology for the job-shop scheduling problem based on intuitionistic fuzzy sets. *International Journal of Production Research*, Vol. 51, No. 17, 5100-5119, doi: 10.1080/00207543.2013.793425.
[23] Gao, K.Z., Suganthan, P.N., Pan, Q.K., Tasgetiren, M.F. (2015). An effective discrete harmony search algorithm for flexible job shop scheduling problem with fuzzy processing time, *International Journal of Production Research*, Vol. 53, No.19, 5896-5911, doi: 10.1080/00207543.2015.1020174.
[24] Palacios, J.J., González-Rodríguez, I., Vela, C.R., Puente, J. (2017). Robust multiobjective optimisation for fuzzy job shop problems, *Applied Soft Computing*, Vol. 56, 604-616, doi: 10.1016/j.asoc.2016.07.004.
[25] Kacem, I., Hammadi, S., Borne, P. (2002). Pareto-optimality approach for flexible job-shop scheduling problems: Hybridization of evolutionary algorithms and fuzzy logic, *Mathematics and Computers in Simulatio*n, Vol. 60, No. 3-5, 245-276, doi: 10.1016/S0378-4754(02)00019-8.
[26] Zheng, Y.L., Li ,Y.X., Lei, D.M. (2012). Multi-objective swarm-based neighborhood search for fuzzy flexible job shop scheduling, *The International Journal of Advanced Manufacturing Technolo*gy, Vol. 60, No. 9-12, 1063-1069, doi: 10.1007/s00170-011-3646-2.
[27] Lei, D.M. (2012). Co-evolutionary genetic algorithm for fuzzy flexible job shop scheduling, *Applied Soft Computing*, Vol. 12, No. 8, 2237-2245, doi: 10.1016/j.asoc.2012.03.025.
[28] Gao, K.Z., Suganthan, P.N., Pan, Q.K., Chua, T.J., Chong, C.S., Cai, T.X. (2016). An improved artificial bee colony algorithm for flexible job-shop scheduling problem with fuzzy processing time, *Expert Systems with Applications*, Vol. 65, 52-67, doi: 10.1016/j.eswa.2016.07.046.
[29] Azadeh, A., Hatefi, S.M., Kor, H. (2012). Performance improvement of a multi product assembly shop by integrated fuzzy simulation approach, *Journal of Intelligent Manufacturing*, Vol. 23, No. 5, 1861-1883, doi: 10.1007/s10845-011-0501-0.
[30] Shadrokh, S., Kianfar, F., (2007). A genetic algorithm for resource investment project scheduling problem, tardiness permitted with penalty, *European Journal of Operational Research*, Vol. 181, No. 1, 86-101, doi: 10.1016/j.ejor.2006.03.056.
[31] Storn, R., Price, K. (1997). Differential evolution – A simple and efficient heuristic for global optimization over continuous spaces, *Journal of global optimization*, Vol. 11, No. 4, 341-359, doi: 10.1023/A:1008202821328.
[32] Bean, J.C. (1994). Genetic algorithms and random keys for sequencing and optimization, *ORSA journal on computing*, Vol. 6, No. 2, 154-160, doi: 10.1287/ijoc.6.2.154.

[33] Qian, B., Wang, L., Huang, D.X., Wang, W.L., Wang, X. (2009). An effective hybrid DE-based algorithm for multi-objective flow shop scheduling with limited buffers, *Computers & Operations Research*, Vol. 36, No. 1, 209-233, doi: 10.1016/j.cor.2007.08.007.

[34] Zhang, R., Wu, C. (2011). A hybrid differential evolution and tree search algorithm for the job shop scheduling problem, *Mathematical Problems in Engineering*, Vol. 2011, Article ID: 390593, doi: 10.1155/2011/390593.

[35] Li, J.Q., Pan, Q.K., Gao, K.Z. (2011). Pareto-based discrete artificial bee colony algorithm for multi-objective flexible job shop scheduling problems, *The International Journal of Advanced Manufacturing Technology*, Vol. 55, No. 9-12, 1159-1169, doi: 10.1007/s00170-010-3140-2.