Hole Drilling Route Optimization in Printed Circuit Boards Using Far-to-Near Metaheuristics:

Optimizing the Hole Drilling Route via Far-to-Near Metaheuristic

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ABSTRACT

Drilling holes in printed circuit board (PCB) is usually realized by computer numerical controlled machine (CNCM). In fact, affecting an optimal shortest drilling holes route for the CNCM will improve its processing time and inevitably its efficiency. This paper presents a new metaheuristic named far-to-near (FtN) in order to optimize the shortest drilling holes route in PCB. The generated solution will be used as an execution plan for robotic arm in CNCM. Several numerical applications illustrate the performance of the proposed metaheuristic FtN in order to generate the shortest drilling route and also to find the optimal circuit when changing the position of the initial starting position of the robotic arm.

KEYWORDS

Artificial Intelligence, Computer Science Applications, Dhouib-Matrix Concept, Engineering, Far-to-Near, Holes Drilling Route Optimization, Metaheuristic, Printed Circuit Board

1. INTRODUCTION

Drilling holes in a Printed Circuit Board (PCB) is a combinatorial problem. This process is usually done through robotic arm in Computer Numerical Controlled Machine (CNCM) where this robotic arm will move to each hole (the position of each hole is presented by a specific coordinate *x* and *y*) then drill it. Minimizing the total drilling distance will automatically minimize the total time spent by the robotic arm to move between all holes which will agreeably increase the productivity of the CNCM. Thus, the main objective for this problem is to minimize the total distance of drilling path.

Several optimization methods are exploited to minimize the total movement of tool path for CNC manufacturing machine. The Simulated Annealing metaheuristic is developed to minimize the robotic holes drilling route in Daadoo et al. (2018). The Discrete Teaching Learning-Based Optimization metaheuristic in parallel structure in order to optimize the mouvement of tool path for holes drilling in PCB is designed in (Rico-Garcia et al., 2020). The Intelligent Water Drops is proposed in Srivastava (2015). The Ant Colony Optimization metaheuristics is focused in Saealal

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et al. (2012), Abbasa et al (2011) and Ghaiebi & Solimanpur (2007). The Variable Neighborhood Search metaheuristic with Multiple Ant Colony Optimization metaheuristic are combined in Liang et al. (2013) in order to increase the manufacturing capacity of the drilling operation in multiobjective environment (regarding makespan and total tardiness objectives) for Taiwan PCB industries. The Genetic Algorithm is developed via MATLAB software in Pezer (2016).

Furthermore, primary presentation of Artificial Intelligence System application in Computer Aided Process Planning and manufacturing is illustrated in (Kumar, 2017). The local search method entitled Record-to-Record Travel metaheuristic which is derived from the Simulated Annealing metaheuristic is employed in Kentli and Alkaya (2009). The Genetic Algorithm is deigned to reduce the time of the travel path for the CNCM in Lai et al. (2019). The Harmony Search Aalgorithm is applied and the numerical results are then compared to Genetic Algorithm in Kim et al. (2019). A hybrid method is designed to minimize the processing time for printed circuit board in Ancău (2009). The Cuckoo Search method is focused to minimize the drilling path in Lim et al. (2014). Also, a combination between the Cuckoo Search method and Genetic Algorithm in order to optimize the holes drilling is developed in Kanagaraj et al. (2014) and Lim et al. (2016).

Moreover, the Particle Swarm Optimization techniques is adapted in Adam et al. (2010), Onwubolu and Clerc (2004), Zhu (2006) and Zhu and Zhang (2008). Also, the Tabu Search method is applied in Kolahan and Liang (1996). Additionally, the Genetic Algorithm is proposed in Liu and Liu (2010), Quedriet al. (2007), Sigl and Mayer (2005). Khodabakhshi and Hosseini (2021) presented a literature revue and remaining challenges for drilling tool path minimization problem. A combination of the Open Architecture Control technology (which is maintained by the G-code data model) and the Ant Colony Optimization metaheuristic is developed by Hatem et al. (2021) in order to minimize the travel path time.

In this study the novel local search metaheuristic Far-to-Near (FtN) is used to minimize the total drilling holes distance and also to find the optimal circuit when changing the position of the initial starting position of the robotic arm. In fact, FtN is recently invented to perform the intensification step of the iterated Dhouib-Matrix-3 (DM3) metaheuristic in Dhouib (2021a) and the multi-start Dhouib-Matrix-4 (DM4) metaheuristic in Dhouib (2022). FtN is based on a three simple structures: 1) an organized neighbor selection 2) three perturbation techniques and 3) a thresholding accepting criterion.

Actually, FtN is a part of the Dhouib-Matrix (DM) concept. DM proposes several optimization methods for combinatorial problems. For the Transportation Problem (TP) the Dhouib-Matrix-TP1 (DM-TP1) heuristic is proposed and proved principally to solve TP with crisp values in Dhouib (2021b), fuzzy environment in Dhouib (2021c) and neutrosophic domain in Dhouib (2021d). For the Travelling Salesman Problem (TSP) the Dhouib-Matrix-TSP1 (DM-TSP1) is proposed primary in Dhouib (2021e). DM-TSP1 is tested on several fuzzy TSP in Dhouib (2021f), Miledi et al. (2021) and Dhouib & Dhouib (2021). Also, DM-TSP1 is proved for TSP under intuitionistic domain in Dhouib (2021g). Moreover, DM-TSP1 is proposed to perform TSP in neutrosophic environment in Dhouib (2021h) and Dhouib (2021i).

In fact, the main contribution in this paper is the novel manner to minimize the drilling path in PCB using the novel FtN metaheuristic. Several numerical case studies are used to present the performance of FtN with graphical representation of the generated optimal solution. Moreover, the results of the FtN are compared to result of other metaheuristics presented in the literature.

This paper is structured as follows. Next section presents the problem of holes drilling route in printed circuit board. Section 3 describes the proposed local search metaheuristic FtN. Section 4 illustrates the experimental results of the FtN metaheuristic on several case studies from the literature; the results are compared to Particle Swarm Optimization, Ants Colony System, Cuckoo Search and Hybrid Taguchi Genetic Algorithm. Finally, section 5 gives the conclusion and the future perspectives for the FtN.