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Cutting path as a Rural Postman Problem: solutions by Memetic Algorithms

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Abstract. The Rural Postman Problem (RPP) is a particular Arc Routing Problem (ARP) which consists of determining a minimum cost circuit on a graph so that a given subset of required edges is traversed. The RPP is an NP-hard problem with significant real-life applications. This paper introduces an original approach based on Memetic Algorithms - the MARP algorithm - to solve the RPP and, also deals with an interesting Industrial Application, which focuses on the path optimization for component cutting operations. Memetic Algorithms are a class of Metaheuristics which may be seen as a population strategy that involves cooperation and competition processes between population elements and integrates "social knowledge", using a local search procedure. The MARP algorithm is tested with different groups of instances and the results are compared with those gathered from other publications. MARP is also used in the context of various real-life applications.

Keywords: Cutting Path Application, Rural Postman Problem, Memetic Algorithms.

1 Introduction

Many industries need to determine good layouts and path planning to cut pieces using various cutting tools and procedures that are appropriate for the materials in use. This work is motivated by specific continuous process path-cutting applications, meaning that the cutting tool never leaves the cutting surface, and there are no restrictions with regard to completely cutting a piece after initiation. These applications are modeled as Rural Postman Problems (RPP) and solved as such. Furthermore, an original method based on Memetic Algorithms (MA) - MARP algorithm - is introduced and used to solve the RPP. Therefore, the paper is twofold:

1. A new algorithm for the RPP is presented and tested;
2. Potential applications to path cutting planning are illustrated.

The RPP is more general than the Chinese Postman Problem (CPP), a well-known Arc Routing Problems (ARP), which consists of finding the shortest circuit that traverses each edge of a graph at least once. These edges can be directed, undirected or both. In the case of RPP, not all of the edges have to be traversed by the circuit, only those included in a specified subset of required edges. The RPP is applied to a variety of practical contexts which include mail delivery, garbage collection (Ghiani et al. [1] present a case study modeled as a particular ARP), street cleaning, road gritting, meter reading and laser plotter applications [2, 3,4].

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