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EXPLORING NEW CONSTRUCTIVE ALGORITHMS FOR THE LEATHER NESTING PROBLEM IN THE AUTOMOTIVE INDUSTRY

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ABSTRACT:

In this paper, we address the leather nesting problem that arise typically in the automotive companies. In this problem, irregular shapes (parts of car seats) have to be cut from another larger shape (natural leather hide). The problem is defined over two dimensions, and all the shapes are irregular and may contain different quality zones due to the natural origin of the leather hides and to particular quality requirements for the different parts of the seats. Our study is based on the real case of a large multinational company.

We explore different approaches to solve this problem based on constructive procedures. The details of each of these procedures have been discussed. We also have described how to use the no-fit polygon in the context of these particular nesting problems. Some preliminary results on real instances have been accomplished.

ALGORITHMS FOR THE LEATHER NESTING PROBLEM

Given a set of geometric shapes, the aim of a 2-Dimensional Cutting Stock Problem is to find the optimal layout for these shapes inside a larger shape that may be a piece of wood, metal or a leather hide. The objective of these problems may be to minimize the wastage of material, to maximize the area of the used space, or to maximize the value of the parts that are placed inside the larger shape. Cutting stock problems are crucial processes in many fields of industry, such as textile, leather, wood, steel and glass. The importance of these problems is related to how effectively the raw material is used and, depending on its cost and quantity, the financial impact may be decisive.

The particular definition of the cutting stock problems depends heavily on the industry to which they apply. There are limitations in terms of the orientation of the shapes to be cut in the textile and wood industries, for example. Some raw-materials have defective areas such as knots and holes in the wood industry, or scars and cuts in the leather industry. The geometric aspect of the shapes and materials may be very different from one industry to the other. For example, in most cases, the raw-material has a rectangular shape (such as the rolls in the textile industry). In some cases, the shapes may be highly irregular, as happens for example in the leather industry. In the latter case, the small shapes that must be cut from these raw materials can vary from simple rectangles to extremely irregular polygons. Cutting stock problems involving irregular shapes are called *nesting problems*.

One of the hardest applications of cutting stock problems is found in the leather industry. Companies operating in this field produce usually shoes, clothes, furniture or car seats. The raw materials used to produce these products are leather hides, which, as a natural product, may have defects, holes and different quality zones. In some cases, the parts to be cut from these hides are subject to some constraints, such as the direction of the cuts that may forbid a shape to be rotated. When no such limitation is required, the problems become even more difficult. This situation happens typically in the automotive industry. Additionally, in these cases, the parts of the car seats may also have quality zones that are directly related to the location of the part within the car seat. This feature increases the complexity of the problem since some regions of the part may overlap certain quality zones of the hide, while others must not. In this paper, we address precisely this more general leather nesting problem.

While many researchers addressed the nesting problem with some degrees of regularity for the shapes (large rectangular shapes, no quality zones), the most general leather nesting problem has been poorly studied in the literature. This fact may be explained by its inherent complexity.

In our work, we propose a set of new constructive heuristics for the general leather nesting problem arising in the automotive industry. We address the problem where all the shapes are irregular and may contain holes, defects and quality zones. Our approaches are based on the computation of no-fit polygons. We already have performed some computational experiments based on real instances.

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