Parallel Hyperheuristics for a MultiObjectivised 2D Packing Problem

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I. INTRODUCTION

Bin Packing Problems are combinatorial NP-hard problems in which objects with different shapes must be packed into a finite number of bins. They have many practical applications as filling up containers. In this work, the 2D Bin Packing Problem (2DPP) proposed in the Genetic and Evolutionary Computation Conference 2008 has been considered. The best results for the 2DPP contest instance were obtained with a mono-objective Memetic Algorithm (MA). However, subsequent studies have concluded that stagnation may occur with this approach for other instances.

Multiobjectivisation [1] refers to the reformulation of originally mono-objective problems as multi-objective ones. It can be performed by aggregating an alternative objective function. Multiobjectivisation has been successfully applied to 2DPP. However, the approach has two main drawbacks: the proper artificial objective depends on the instance to solve, and the time required to obtain high-quality solutions is very high.

In order to avoid such drawbacks parallel hyperheuristics [2] might be applied. A hyperheuristic solves optimisation problems indirectly by recommending which solution method to apply at which stage of the solution process. The main aim of the research has been to solve the 2DPP with a model that avoids the drawbacks of the aforementioned strategies.

II. ACHIEVEMENTS

The parallel model proposed in [3] (DYN) has been applied to the 2DPP. It merges the island-based model with the hyperheuristics principles. The hyperheuristic allows changing in an automatic way the algorithms, parameters and artificial objective functions that are used in the islands. The selected hyperheuristic has been the one named HH_Imp. The low-level configurations have been constituted by combining two different MAS with eight different ways of defining the artificial objective for the multiobjectivisation. Computational tests have been performed with two different instances [4]. Results for the first instance are shown in this report.

The adaptation level of HH_Imp can be tuned with the parameter \( n \). It indicates the number of previous executions that are considered for performing the estimations. The aim of the first experiment has been to analyse the sensitivity of the model to such a parameter. The best fitness values have been obtained when no information have been discarded (\( n = \infty \)).

Table I

<table>
<thead>
<tr>
<th>Success Ratio</th>
<th>25 %</th>
<th>50 %</th>
<th>75 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best_DYN</td>
<td>2400</td>
<td>6000</td>
<td>12000</td>
</tr>
<tr>
<td>Worst_DYN</td>
<td>3000</td>
<td>19200</td>
<td></td>
</tr>
<tr>
<td>UNI</td>
<td>7800</td>
<td>18600</td>
<td></td>
</tr>
</tbody>
</table>

The DYN model has been compared with a dynamic island-based model that assigns the resources uniformly among the low-level configurations (UNI). Table II shows the times required to obtain different success ratios with the best, and worst DYN models, and with UNI. The best DYN model has a faster convergence than the UNI approach. Moreover, differences between the best and worst DYN models are noticeable.
A scalability analysis has also been performed. The parallel model has been executed with up to 128 slave islands. Figure 1 shows the boxplot of the fitness achieved after 1.5 hours, for different number of slaves. It also shows the boxplot of the best sequential approach. The advantages of incorporating more slaves into the model are clear. In order to measure the obtained improvement, the run-length distributions have been used. Figure 2 shows the run-length distributions for each parallel model. It shows that, as more islands are used, the parallel approaches are able to obtain higher success ratios using less time.

The main achievement of the research has been to design a model with the following benefits. First, the time required to obtain high-quality solutions has been drastically reduced. Moreover, the new parallel model has made possible to integrate the usage of several optimisation strategies with different artificial objectives in a single run. Since the selection of the proper alternative objective is performed in an automatic way, and in a single run, the time saved is higher than the one that can be observed in the run-length distribution. In addition, the usage of the hyperheuristic highly improves the usability of the model.

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REFERENCES