THE USE OF GENETIC ALGORITHMS TO SOLVE A PLANT LAYOUT PROBLEM

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RESUMEN

This paper conducts an Genetic Algorithm application to the plant layout problem. Usually, this problem was focused as one of the optimization kind. However, the solutions obtained by these means could rarely be implemented without previous designer revision. Not only, are the GA capable of efficiently solving complex optimization problems, but allow for several constraints to be included in the analysis

Solutions obtained from both –traditional optimization and GA- are compared. The prior was the result of using CORELAP program.

Palabras clave: Layout, Genetic Algorithm, heuristic.

INTRODUCTION

The problem of distributing a plant or facility involves calculating an as effective as possible physical distribution of the resources needed by a company to carry out its productive activities (whether these be staff, equipment or materials. The layout applied after analysis of data about the plant was traditionally one that maximizes some kind of function, whether it be minimization (cost of maintenance or moving of pieces) or maximization the number of adjacencies collected in a matrix qualitatively. Solutions, however, could rarely be implemented without prior revision and the personal intervention of the analyst, who was obliged to make modifications so that they adapted properly.

Since their introduction in 1975, Genetic Algorithms have proved themselves capable of resolving combinatorial optimization problems that would prove enormously complicated for conventional techniques. This article presents an application of this methodology to the field of plant layout. The structure of the article is as follows: the next two sections give a concise description of Genetic Algorithms and plant distribution. Section 4 describes a practical application to an imaginary company that has 6 departments. Solutions are expounded in the fifth section, and conclusions are drawn in the sixth and final section.

GENETIC ALGORITHMS

Genetic Algorithms (abbreviated to GAs) came to the fore in the late 60´s through the work of Holland (1975). A high percentage of the applications that GAs are used for involve resolving optimization problems, and a solution which may not be optimum but certainly is a good approximation to an optimal one is often the outcome of using GAs.
GAs are based on three basic stages: Selection, Reproduction and Replacement, which are all carried out a certain number of times depending on how complex a particular problem is. Each repetition of a stage, or iteration, is called a generation (Goldberg 89) (Michalewicz, 94). One of the hallmarks of GAs is that they work with a population of possible solutions, in contrast to other heuristic search methods, which work with a single solution.

PLANT LAYOUT. THE CORELAP PROGRAMME.

A plethora of authors (Immer-1950, Nadler-1961, Reed-1961) have developed procedures to facilitate the layout designer’s job. In 1961 Muther introduced the method known as Systematic Planning Layout (SPL) which has since been widely used; many of the algorithms used in software programs having been based on it. The technique used the REL matrix, with boxes where the desirability of two particular departments being next to each other in the plant layout is marked using A-E-I-O-U-X proximity ratios, and the FROM-TO matrix, which reflects the importance of materials flow between two departments.

Corelap program.

CORELAP (Computerised Relationship Layout Planning) was launched by the department of industrial engineering of Northeastern University under the leadership of Professor James Moore. It is essentially a construction program. Generating a layout with this program involves confronting the following two questions: firstly, the order in which departments will be placed is defined; This is known as the Placement Sequence Calculation. Then, the department’s relative position, its physical location in space, must be established.

Placement is made in a cell-scheme which is unaware of the original shape of the real plant. The program maintains the rectangular shape of departments. Decisions as to the final positioning will be based on position ratios and borderline length.

PRACTICAL APPLICATION

The plant distribution problem that we will use to compare the fitness of solutions generated by genetic algorithms and the CORELAP program involves 6 departments: 1- Office (400 m²), 2- Reception (200m²), 3- Polishing (800m²), 4- Lathe Turning (600m²), 5- Assembly (1000m²), and 6- Warehouse (1500m²) to be fitted into a plant, measuring 70m x 50m.

The traditional table of interdepartmental relations corresponding to the above example and produced by the expert according to this experience and the information collected is showed in the following table:
### RESULTS

Starting at the REL matrix in table 1 and with the numeric values assigned to the proximity ratios (an option that Corelap offers the designer) the order of department placements is 2. Reception (Redp), 1. Offices (Oficina), 6 Warehouse (Almacén), 5 Assembly (Montaje), 3, Polishing (Pulido) and 4 Lathe turning (Torneado).

This order affects the ensuing replacement procedure. In the example a matrix with squares that represent 50 m² has been used.

#### Table 1: interdepartmental relations.

<table>
<thead>
<tr>
<th>REL MATRIX</th>
<th>Office</th>
<th>Reception</th>
<th>Polishing</th>
<th>Lathe Turning</th>
<th>Assembly</th>
<th>Warehouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td></td>
<td>A</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>E</td>
</tr>
<tr>
<td>Reception</td>
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<td></td>
<td>E</td>
<td>O</td>
<td>U</td>
<td>U</td>
</tr>
<tr>
<td>Polishing</td>
<td></td>
<td></td>
<td>I</td>
<td>U</td>
<td>O</td>
<td></td>
</tr>
<tr>
<td>Lathe Turning</td>
<td></td>
<td></td>
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<td></td>
<td>I</td>
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</tr>
<tr>
<td>Assembly</td>
<td></td>
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<td></td>
<td></td>
<td>E</td>
</tr>
<tr>
<td>Warehouse</td>
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</tr>
</tbody>
</table>

Evaluation of the above distributions is made by applying the following expression: \[ \sum \sum CR_{ij} \cdot d_{ij} \], where \( d_{ij} \) is the distance between departments that the program will calculate taking the centroids of each section as a reference point, and \( CR_{ij} \) is the proximity ratio that unites them. A low value would indicate a good layout. The value obtained using the traditional method (fig. 1) is 1.545,65, whilst the one for the solution obtained with genetic algorithms, which is shown in figure 2, is 824,4.

### CONCLUSIONS

As the above results clearly show, the quality of the solution provided by genetic algorithms is noticeably better than the one that CORELAP provides. However, it should be noted that the methods, although similar in the sense that both are heuristic, are not
altogether comparable, as using GAs means that different kinds of restrictions can be incorporated. This is not feasible with the CORELAP program.

REFERENCIAS


Muther, R. (1961), Systematic Layout Planning. Industrial Education Institute, Boston.
