Assignment 2 - Factor Influence Analysis

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The objective of this task was to identify the interactions between two independent variables (optimization techniques and matrix sizes) and the impacts of these on the number of branch and cache loads/misses (dependent variables). The numbers used in this analysis were taken from first assignment and were analysed from the perspective of a 2^2 factorial design. The results are shown as follows.

1. Factor Influence Analysis

The independent factors, their respective levels and the influence of each on the analyzed metrics are shown below in the following tables.

Factor	Levels
Opt. Technique	Loop Unrolling Loop Interchange
Matrix Size	100 1000

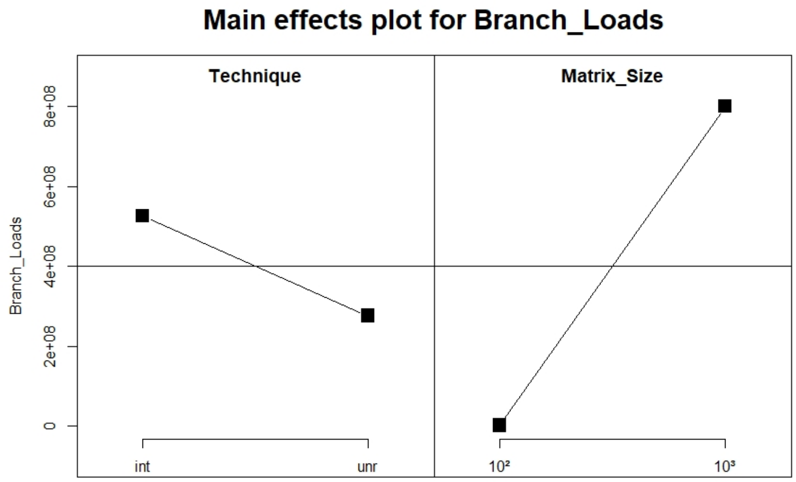
Table 1: Levels of the two independent factors according 2^2 factorial design.

Factor	Branch Loads	Branch Misses	Cache Loads	Cache Misses
Opt. Technique	8.14%	0.62%	0.16%	30.85%
Matrix Size	83.73%	98.67%	99.68%	38.30%
Opt. Technique and Matrix Size	8.11%	0.71%	0.16%	30.85%

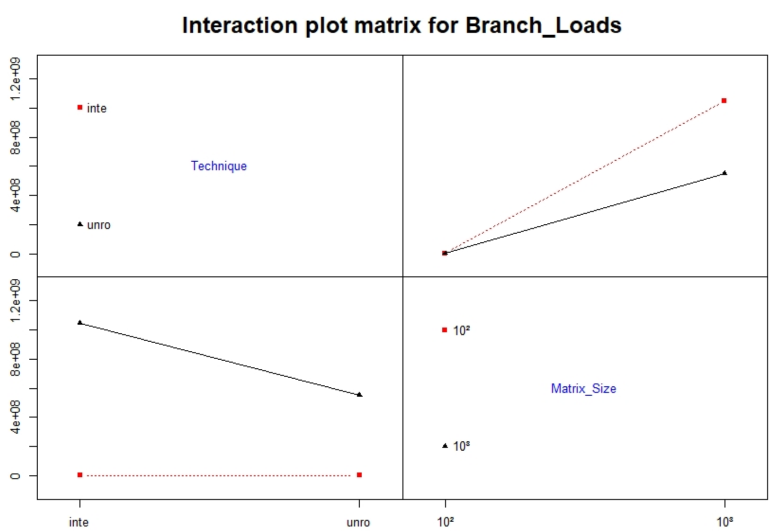
Table 2: Levels of the two independent factors according 2^2 factorial design.

The analyzes made for each of the dependent variables generated two graphs called "Main effects graph" and "Interaction graph". The results are discussed in the next subsections.

1.1 Branch Loads



(i)



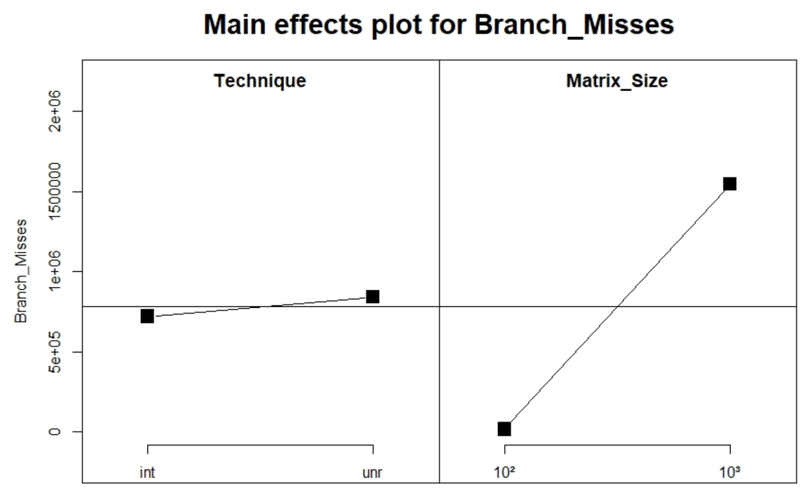
(ii)

Figure 1: (i) Main Effect and (ii) Interaction plots for Branch Loads

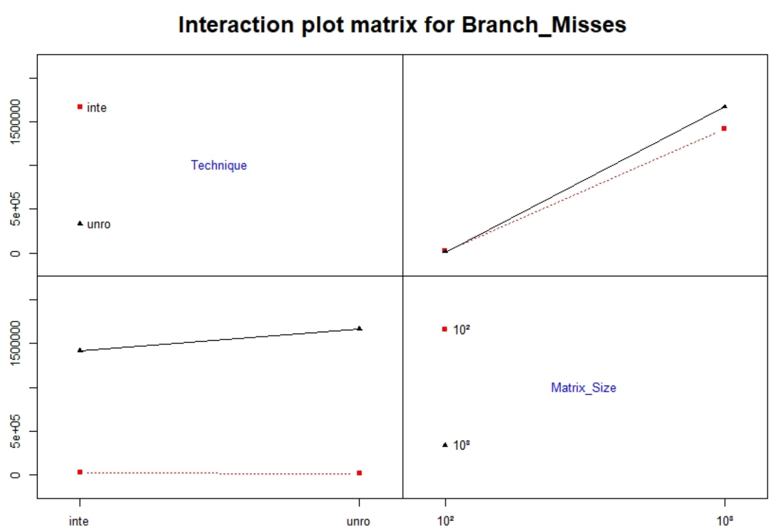
The effects of the Techniques on Branch Loads do not appear to be significant when compared to the effect caused by Matrix Size values. As the analysis of the main effect shows, the difference between the number of Branch Loads when the Matrix Size is changed is greater than when the Technique is changed.

However, in terms of interactions, there is an small interaction between the independent variables as shown in Figure 1 (ii). The changes are more significant when the Interchange Technique is confronted with the change in the Matrix size. However, a smaller interaction occurs when the Unrolling Technique is faced with changing the size of the matrix. This shows that the Matrix Size plays an important role in defining the number of branches taken, especially in combination with different optimization techniques.

1.2 Branch Misses



(i)



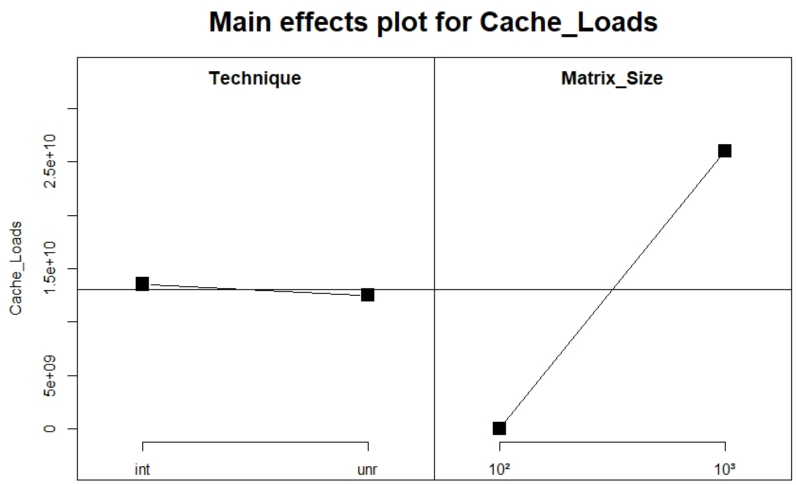
(ii)

Figure 2: (i) Main Effect and (ii) Interaction plots for Branch Misses

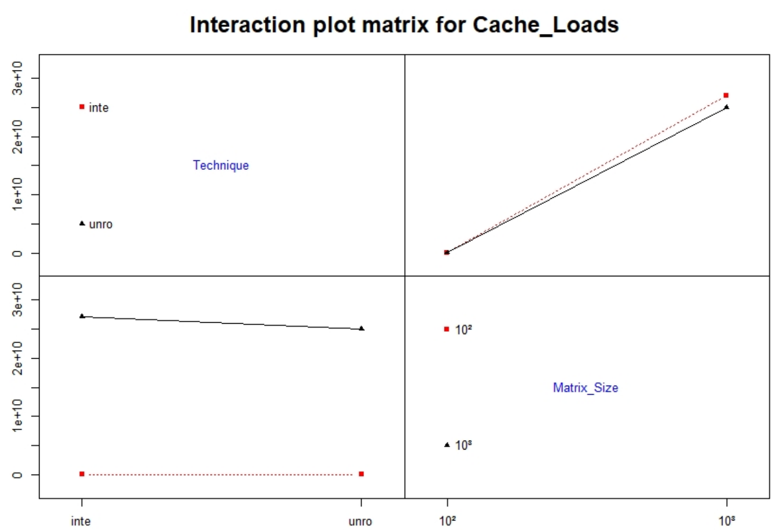
The number of Branch Misses seems to be more influenced by the Matrix Size than by Optimization Technique. As shown in Figure 2 (i), there is a minimal increase in Branch Misses when the technique is changed, which does not occur with the different matrix sizes. The graph shows that there is a main effect for the variable "Matrix_Size", so that size 10^3 has a higher Branch Misses rate than size 10^2.

As shown in Figure 2 (ii), the lines are almost parallel, which indicates that the interactions between the independent variables are not so significant.

1.3 Cache Loads



(i)

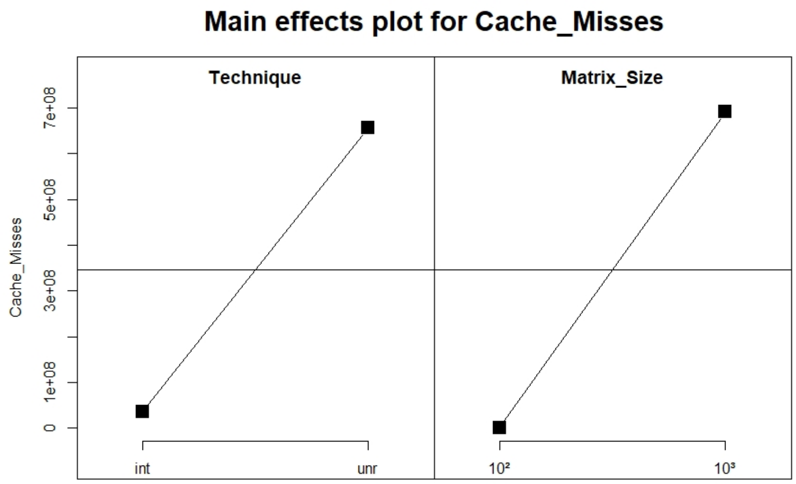


(ii)

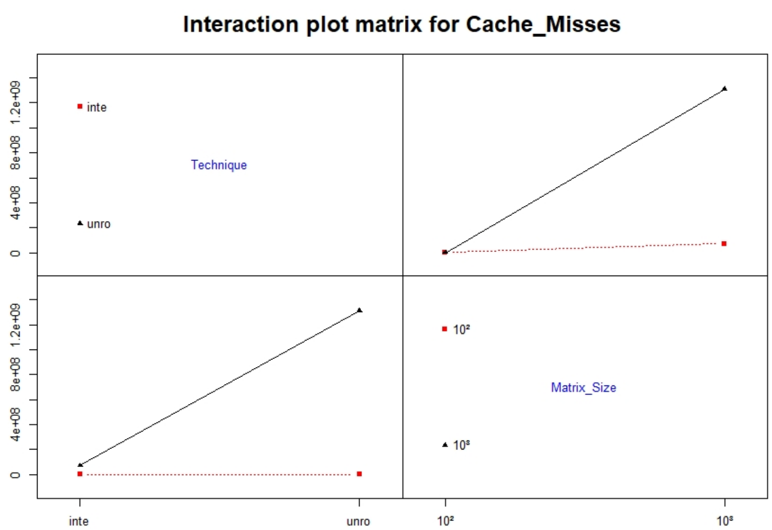
Figure 3: (i) Main Effect and (ii) Interaction plots for Cache Loads

The results for Cache Loads were almost the same for Branch Misses: there is main effect for Matrix Size so that size 10^3 scored higher than size 10^2 on the number of Cache Loads (see Figure 3 (i)). In terms of interactions between the two variables, they are infimous, since the lines are almost parallel as Figure 3 (ii) shows.

1.4 Cache Misses



(i)



(ii)

Figure 4: (i) Main Effect and (ii) Interaction plots for Cache Misses

The impacts of the independent variables on the number of Cache Misses are the most notable. There are significant main effects for both variables so that Loop Unrolling scored higher than Interchange Technique and Matrix Size 100 scored higher than M.S. 1000 on number os Cache Misses. The situation is no different with the interactions: the variables interact significantly with each other, so that, for the Loop Unrolling technique, the Matrix Size 1000 scored higher than M.S. 100. However, for the Loop Interchange technique, the difference between the results for matrix sizes 100 and 1000 was insignificant.

It is known that the loop unrolling technique can increase the number of cache failures due to the increase in the size of the code, which makes the code not fit in the instruction cache, thus decreasing the performance of the code in terms of cache access.

2. Conclusion

In general, as shown in the results, the independent variable that most influences the four metrics analyzed (Cache Loads, Cache Misses, Branch Loads and Branch Misses) is the Matrix Size, whose main effects were the most significant in all of them.