

REVIEWER REPORT

for the dissertation of Georgi Evtimov on the topic "Metaheuristic methods for solving cutting problems"

by Prof. Dr. Ivan Dimov, Department of Parallel Algorithms, Institute of Information and Communication Technologies to the Bulgarian Academy of Sciences (IICT-BAS)

By order № 252 / 28.10.2021 of the Director of IICT-BAS I have been confirmed as a member of the Scientific Jury in connection with the procedure for obtaining the educational and scientific degree "Doctor" in doctoral program 4.6, professional field "Informatics and Computer Science" by Georgi Evtimov with a dissertation on "Metaheuristic methods for solving cutting problems", supervisor Prof. Dr. Stefka Fidanova, IICT-BAS. At the first meeting of the Scientific Jury, held on November 9, 2021 at IICT-BAS, I was elected a reviewer.

1. Field of research, relevance, goals and objectives

The presented dissertation of Georgi Evtimov is focused on an indisputably current and developing field of informatics and mathematical modeling.

The dissertation is dedicated to the development and research of effective metaheuristic methods and algorithms for solving cutting problems. The research work presented in the dissertation is focused on technological innovations and is one of the dynamic areas of modern industry. The motivation and the object of application of this work comes from the construction industry and in particular from the production of steel structures. One of the important activities in this area is the need to cut out a number of details.

This statement is a special case of the general mathematical problem for optimal cutting. The practical task for optimal cutting consists in the following task: a certain material is set (for example, in the textile industry it is fabric, in building constructions it is metal sheets) and a large number of often different, details. It is necessary to cut out the necessary details while minimizing the cost of material. This task was mathematically formulated many years ago, initially in connection with the industrialization of garment production. The topic of the dissertation is undoubtedly relevant, as it finds applications in many industrial productions.

The main objectives of the dissertation are two, namely:

- Optimal cutting of linear elements with minimal waste;
- Optimal cutting of irregularly shaped two-dimensional elements with minimal waste.

To achieve these goals, the following tasks are formulated:

- Task 1. Development of an algorithm for solving the problem of one-dimensional (linear) cutting;
- Task 2. Development of an algorithm for solving the problem of cutting two-dimensional elements;
- Task 3. Software implementation of the developed algorithms and comparisons of real construction sites with existing in practice methods of cutting.

2. Knowledge of the state of the problem by the dissertation

It is clear to me that the dissertation Georgi Evtimov knows the state of the problem since he himself practically works successfully in this field, offering real services to clients.

The author of the dissertation knows the topics well considered, the current state and the achieved results in solving the set tasks.

3. Research methodology

The research methodology in this dissertation includes two areas related to: (1) cutting of linear profiles (steel bars, image profiles, etc.) or cutting and (2) cutting of two-dimensional (flat) plates of steel sheets. The first area concerns one-dimensional cutting. No special definitions are introduced for optimization, as it works with one parameter, the length of the element. The task of minimal waste comes down to finding the minimum number of profiles used. Although it is easier than the two-dimensional task, it is also NP complex. The approach used in the dissertation is the ant method.

The second area is cutting. The data includes an input list of a number of planks (called input polygons) that need to be arranged as tightly as possible in a polygon called a baseline. When searching for a possible location of the input polygons, rotation and mirror image can be applied. Once the location of the input polygon is selected, it is necessary to apply the algorithm for "subtraction" ("cutting") of two polygons. This is done in order to find a location for the next input polygon in the rest of the main polygon. This (cut) plate is then removed from the list of input plates. This is repeated until all the bars on the input list are exhausted. The overall solution (the set of planks) is then evaluated by the metaheuristic algorithm.

4. Characteristics and evaluation of the contributions of the dissertation

Georgi Evtimov's dissertation contains 143 pages, 39 tables, figures 143, algorithms 10, literature sources 117.

The main **scientific and applied research contributions** in the dissertation can be formulated as follows.

Scientific contributions:

- An algorithm for optimal cutting in one-dimensional space has been developed;
- An algorithm for optimal cutting in two-dimensional space has been developed;
- A method for two-dimensional cutting based on hybrid optimization has been developed;

I believe that the dissertation has two main scientific and applied contributions, namely:

- Software implementation of the algorithm for one-dimensional cutting;
- Software implementation of the algorithm for two-dimensional cutting.

I agree with the statement made in the dissertation that the results obtained can be used in various fields of science and engineering practice, namely:

- When designing buildings and facilities;
- When designing the wear of parts in machines as well as the design of mechanisms;
- In earth mechanics - soil consolidation, as in other areas where CAD systems are used.

The dissertation consists of an introduction, three chapters and a conclusion.

The introduction substantiates the relevance of the topic of the dissertation. An overview of the existing results is made. The goals and tasks of the dissertation are formulated.

The second chapter introduces basic concepts of computational geometry, giving basic definitions, finding a box of a polynomial, intersecting two lines, a point in a polygon, intersecting two polygons, operations with polygons such as sets, enveloping a set of points and reducing on the tops of the landfill.

In the third chapter the problem of one-dimensional cutting is considered.

In the fourth chapter the problem of two-dimensional cutting is considered.

The fifth chapter "Conclusion" contains the list of publications, approbation of the results, the contributions are formulated and a declaration of originality is given.

5. Publications on the dissertation

The dissertation is based on **8 scientific publications, 4 of which have been published in specialized international publications with IF or SJR rank** upon request of at least three scientific publications, at least one of which is in an impact factor journal or in a specialized international publication, according to The Regulations on the Specific Conditions for Acquisition of Scientific Degrees and for Occupying Academic Positions at IICT-BAS. The presented works were published in the period 2015 — 2018. All publications are co-authored. There are no stand-alone publications. I would like to point out at once that

it is natural to work collectively in this area, and that is why I do not see the lack of independent publications as a shortcoming.

The results of this dissertation have been reported at various scientific forums, such as:

- 113th European Study Group with Industry (BGSIAM - 2015);
- 11th Annual Meeting of the Bulgarian Section of SIAM (BGSIAM - 2016);
- 120th European Study Group with Industry (ESGI'120 - 2016);
- 12th Annual Meeting of the Bulgarian Section of SIAM (BGSIAM - 2017);
- 13th Annual Meeting of the Bulgarian Section of SIAM (BGSIAM - 2018);
- Conference on Large-Scale Scientific Computations LSSC'17, Sozopol, 2017;
- Ninth International Conference on Numerical Methods and Applications NM & A'18, Borovets.

The abstract correctly reflects the content and main contributions of the dissertation. It is 64 pages long and contains 114 cited sources.

6. Critical remarks

I have some critical remarks and recommendations to the doctoral student:

- I would recommend an even more in-depth analysis of the existing optimization algorithms for tasks related to optimal cutting and optimal placement of objects. I have noticed that the results of famous authors in this field, such as Beasley, P.Y. Wang, Leeton and others have not been considered in the analysis of literature sources. I recommend the PhD student in his next research to analyze their approaches and comment on them.
- I found inaccuracies in the text of the dissertation and the abstract. There are stylistic and grammatical inaccuracies and errors. I will not list them all, but I will give only a few examples: in the abstract: on page 7 "one-dimensional" instead of "one-dimensional", "comparative" instead of "comparisons"; on page 8: "uses" instead of "uses", etc .; there are also grammatical errors in the dissertation, including on page 132 the name of Prof. Margenov (it is written "Svetoslav" instead of "Svetozar").

I would like to point out that these notes / recommendations do not spoil the good impression of the doctoral student's work and the work done, but they require more precision and attention on the part of the doctoral student.

7. Personal impressions

I know Georgi Evtimov as a doctoral student in the section "Parallel Algorithms" and I have a

good opinion of him. He is motivated to carry out scientific activity, is persistent in his goals and has good organizational skills.

8. Conclusion

The dissertation contains results that have scientific and scientific-applied contribution in the field of professional field "Informatics and Computer Science" and most of them are published in specialized international publications with SJR rank. The presented dissertation meets all the requirements of the Law for the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), as well as the Regulations for implementation of ZRASRB, the Regulations for the conditions for obtaining scientific degrees and holding academic positions in BAS and the Regulations for the specific conditions for acquiring scientific degrees and for holding academic positions at IICT-BAS. The critical remarks in this review do not in any way detract from the results obtained in the dissertation.

The above gives me grounds for a positive assessment of the dissertation, which I propose to the Scientific Jury to award the educational and scientific degree "Doctor" of Georgi Evtimov Evtimov in doctoral program 4.6, professional field "Informatics and Computer Science".

January 27, 2022



/ Prof., Ph.D. Ivan Dimov /