REVIEWER'S OPINION OF FINAL THESIS

I. IDENTIFICATION DATA

Thesis name:	**Surgery planning using branch-and-price algorithm accelerated using machine learning**
Author's name:	**Pavlina Koutecka**
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Computer Science.
Thesis reviewer:	Broos Maenhout
Reviewer's department:	Faculty of Economics and Business Administration, Ghent, Belgium

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	extraordinarily challenging

Evaluation of thesis difficulty of assignment.

The thesis comprised the development of an optimisation approach to schedule surgeries in an operating room and accelerate the combinatorial optimisation via machine learning techniques, which is novel and very challenging, requiring deep insight in the field of study. This thesis corresponds to research that normally a PhD student would do in his later years.

Satisfaction of assignment	fulfilled

Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.

The student has proven to master the difficult optimization concepts and to translate these into workable code. In addition, the student has derived useful machine learning models that are indeed able to accelerate the branch-and-price procedure. The results are excellent and provide proof that developed approaches are satisfactory. Also the structure and writing of the thesis is beyond expectations. It is clear that the student has put tremendous effort in this dissertation.

Method of conception	outstanding

Assess that student has chosen correct approach or solution methods.

The student used a non-trivial approach, i.e. branch-and-price, that is able to outperform standard optimization solvers. Different state-of-the-art machine learning models have been selected and assessed experimentally. I congratulate the student for this rigorous approach.

Technical level	A - excellent.

Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.

The student has learned to design a state-of-the-art solution method and to use standard optimization software. In addition, the student acquired insight in the planning and scheduling of operating room departments. Based on this knowledge the student has been able to outperform existing methods published in the literature.

Formal and language level, scope of thesis	A - excellent.

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The thesis has been structured in an adequate manner. The use of math notations is balanced and concepts are discussed in a comprehensible manner.

Selection of sources, citation correctness	A - excellent.

Present your opinion to student's activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The student has done an elaborated search to connected studies. All relevant sources are mentioned and a good analysis of the literature has been provided.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

The student has proven to conduct research in a scientific correct manner. The results are outstanding, meeting all requirements and will be submitted to an international journal for evaluation.

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

The problem is novel and the required degree of technical implementation is high. A similar approach has not been developed previously in literature such that this work is highly rated and has potential to be published in a top journal.

Questions:

1. You indicate in Section 5.3 (Table 5.4) that the graded ranker significantly outperforms the binary ranker. Can you explain the word 'significantly'? Have you relied on statistical tests to compare results? In addition, it is not clear why the graded ranker performs better compared to the binary ranker for 10 days as number of nodes, column generation iterations and number of pricing problems solved is larger for the former.
2. In the SHAP plots, you observe that a large number of features do not contribute to the predictive value? What is the impact on the computational performance if these features would not be incorporated? Does this accelerate the algorithm?
3. In Section 5.4 (Table 5.5), you employ a fixed number of patterns to be generated before you go back to solving the master problem. However, for a branch-and-price method it is very likely that you will need to generate a lot of columns in the initial nodes of the search tree, whereas in later nodes you will be able to generate only one pattern with suitable reduced cost. Hence, in my believe setting the number of patterns in a dynamic manner could be more fruitful. My question: can the ML approach also learn how many patterns need to be generated in every node and which features do you need?

I evaluate handed thesis with classification grade **A - excellent.**

Date: **2.6.2023**   Signature: Broos Maenhout