THESIS REVIEWER'S REPORT

I. IDENTIFICATION DATA

Thesis title:	Optimization of the $t\bar{t}H$ Selection Including Systematics Using Machine Learning with ATLAS Data
Author's name:	Vladyslav Yazykov
Type of thesis :	master
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Petr Šimánek
Reviewer's department:	KAM FIT CTU

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **challenging**

How demanding was the assigned project?

The most challenging part seems to be the understanding of the domain, i.e. the Atlas data. It is obvious that understanding all the underlying tools and data structures must have been challenging. The development of the particular machine learning solution seems to be rather standard.

Fulfilment of assignment **fulfilled**

How well does the thesis fulfil the assigned task? Have the primary goals been achieved? Which assigned tasks have been incompletely covered, and which parts of the thesis are overextended? Justify your answer.

All the tasks were fulfilled.

Methodology **correct**

Comment on the correctness of the approach and/or the solution methods.

The methodology is correct. The usage of deep learning is somehow motivated, but the usage of FT-Transformer is not. There are many deep learning methods that can be applied to table data. The previous work on Atlas data is well described, but I miss more detailed discussion of SOTA machine learning table data.

Technical level **B - very good.**

Is the thesis technically sound? How well did the student employ expertise in the field of his/her field of study? Does the student explain clearly what he/she has done?

There are multiple design choices in the deep learning approach that are not standard (at least these are not used in the cited literature) that are not explained nor motivated, why is GELU activation used instead on RELU? Why is the student adding LayerNorm in the ResNet model? I understand these changes, but if they are used, they should be at least motivated, explained or cited.

Further, we do not know how exactly Attention is computed or applied in the presented work, FlashAttention is mentioned in the appendix, but it is never stated if it is used.

Formal and language level, scope of thesis **C - good.**

Are formalisms and notations used properly? Is the thesis organized in a logical way? Is the thesis sufficiently extensive? Is the thesis well-presented? Is the language clear and understandable? Is the English satisfactory?

The English of the work is good, the thesis is mostly easy to read, especially the introduction section is easy to understand and well presented. The methodology section is less clear, some parts seem to be unnecessary (e.g. the student explains confusion matrix in detail and never uses it) and possibly too much space is dedicated to some basic methods that are further not used and it is not clear why it is included in the thesis (e.g. deep dive into MLP).
It would be better if all the methods that are used (ResNet, Transformer) are more clearly described, e.g. the setup of the ResNet model is for some reason hidden in the Pre-Processing and Embedding subsection and not it the ResNet subsection. In both ResNet and Transformer definition, the function *embed* is used without properly defining it (it is described in one subsection, but the usage is not clear). Also, it would be better to reference in the text to the appendix where the features

are listed, not only in the thesis structure.

One of the tasks in the thesis assignment is to "compare to existing approaches". While the comparison is done, the previous results are scattered between many subsections, and it is difficult to be certain if it is based on the same data or not. It would be better to compare current results with the previous (i.e., gradient boosting methods) on one place.

Selection of sources, citation correctness **C - good.**

Does the thesis make adequate reference to earlier work on the topic? Was the selection of sources adequate? Is the student's original work clearly distinguished from earlier work in the field? Do the bibliographic citations meet the standards?

The sources are adequate, the original work is distinguished. I believe that the whole subsection "Systematic Uncertainties" lacks any references to literature, while many of the terms used are not a common knowledge. The whole Chapter 3 misses a lot of references, e.g., the binned profile likelihood method.

Additional commentary and evaluation (optional)

Comment on the overall quality of the thesis, its novelty and its impact on the field, its strengths and weaknesses, the utility of the solution that is presented, the theoretical/formal level, the student's skillfulness, etc.

The ML approach is standard now, but it seems to be a important step in the analysis of the Atlas data.

III. OVERALL EVALUATION, QUESTIONS FOR THE PRESENTATION AND DEFENSE OF THE THESIS, SUGGESTED GRADE

Summarize your opinion on the thesis and explain your final grading. Pose questions that should be answered during the presentation and defense of the student's work.

The structure and clarity of the first part is excellent, it is a really good introduction into the domain, and it well motivates the use of machine learning. The methodology part is less readable and sometimes difficult and follow. The domain is very difficult, and the presented methods are a very good step forward in this area. My biggest concerns are the missing motivation behind choosing FT-Transformer, the missing references in the last chapter and the mostly very unclear presentation of the results, especially the comparison to previous results. I would encourage the student to present the results more clearly, e.g. "my best approach is % better than previous SOTA".

My questions:

Why did you choose FT-Transformer and not some other method (TabNet), can you get a better results with some further feature engineering? What are the computational resources you used for the training and how does it compare to gradient boosting methods?

The grade that I award for the thesis is **B - very good.**

Date: **26.8.2023** Signature: