

I. IDENTIFICATION DATA

Thesis name:	Application of Machine Learning for the Higgs Boson Mass Reconstruction Using ATLAS Data
Author's name:	Adam Herold
Type of thesis :	bachelor
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Cybernetics
Thesis reviewer:	Babar Ali
Reviewer's department:	Institute of Experimental and Applied Physics

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment	challenging
<i>Evaluation of thesis difficulty of assignment.</i>	
Reconstructing Higgs boson mass produced in the association of top anti-top quark pairs is a challenging task because of the very busy environment. In different final states, there are lot of physics objects such as leptons, taus, jets, and missing energy (neutrinos).	

Satisfaction of assignment	fulfilled with minor objections
<i>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.</i>	
The assignment is fulfilled in all aspects. I have minor comments please see below.	

Method of conception	correct
<i>Assess that student has chosen correct approach or solution methods.</i>	
A classification neural network technique is developed for training and testing using simulated data. The approach is correct since the task in hand required to reconstruct Higgs mass and separate ttZ background.	

Technical level	B - very good.
<i>Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.</i>	
The data recorded by the ATLAS detector at LHC CERN consists of different physics objects e.g., light leptons, taus, jets etc. I positively evaluate author's ability to work with such complicated data.	

Formal and language level, scope of thesis	C - good.
<i>Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.</i>	
The thesis is concise and well written. I have no objections about the structure if the individual chapters. Citations are used properly. There are quite few repetitions about selection. Section 4.2 is difficult to follow, and it could be more precise. I would have expected detailed but concise explanation about the machine learning and neural network.	

Selection of sources, citation correctness	B - very good.
<i>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.</i>	
The citations are used properly throughout the thesis.	

III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Overall, I positively evaluate all aspects of this thesis. I consider the work done is of good quality and could be very useful for the ttH group within ATLAS.

I evaluate handed thesis with classification grade **B - very good**.

Minor comments:

Equation 1.10, the leading order Feynman diagram for ttZ production is gluon-gluon and not via quark-antiquark.

Page 22: The common selection requires at least three jets. It should require at least four jets and out of them at least one b-jet. In a typical ttH event, we expect at least four jets (see Figure 1.4)

Nomenclature used for the variables in the CNN is difficult to follow. It could be simplified.

Figure 4.1: The description of z-axis is not given in the figure caption

Major comments:

Section 3.4: The narrow selection is used for the particle assignment, and it is stated that the wider selections are not used as the decay channels of those events are different. This is not entirely true. A typical ttW can also give the same final state and mimic the ttH event. While for a ttbar event, one of either light lepton or tau is fake (misidentified) as they originated from another source such as in decays of b flavored hadrons.

Figure 4.2: Separation achieved in MMC inspired loss is comparable with MMC itself. The mean values are smaller. This could be improved by just focusing on Higgs to tau tau decay mode as it is done in MMC case (1.3.2). The additional neutrino originating from anti-top decay has no significant impact in reconstructing Higgs mass.

Question: A classification NN approach is used inspired by the paper ref. [36]. In that paper, they used a stricter requirements e.g number of jets up to 6. Did you try to use the number of jets up to 6?

Question: Did you test the separation between ttH and ttZ if you had use data selection same as of real data? (Figure 4.5).

Date: **24.1.2022**

Signature: