THESIS REVIEWER'S REPORT

I. IDENTIFICATION DATA

Thesis title:	Analyses of heart rate variability in animal models of epilepsy
Author's name:	Jonáš Fér
Type of thesis :	bachelor
Faculty/Institute:	Faculty of Electrical Engineering (FEE)
Department:	Department of Circuit Theory
Thesis reviewer:	Ing. Jan Kudláček, DiS., Ph.D.
Reviewer's department:	Department of Physiology, Second Faculty of Medicine, Charles University

II. EVALUATION OF INDIVIDUAL CRITERIA

Assignment **ordinarily challenging**

How demanding was the assigned project?

The project aim was to develop an algorithm for automatic analysis of rat ECG signals and prediction of the risk of cardiac arrhythmia and sudden unexplained death in epilepsy patient (SUDEP). The assignment was adequate for a bachelor thesis. It did not specify concrete methods which should have been used neither did it specify any required success rate of the developed classifier.

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.

The assignment was fulfilled and the primary goals have been achieved. I would appreciate deeper investigation into R peaks detection and artifact rejection. Prediction of the cardiac arrhythmia and SUDEP risk was not performed because of the lack of data – none of the experimental rats died from SUDEP which was out of the student's control. Classification of the ECG recorded from epileptic vs. naïve rats was a good substitute task.

Methodology **correct**

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

The methods used were largely appropriate. I appreciate that the student implemented most of the methods himself and understood them well. I only have concerns regarding the artifact rejection, see below.

Technical level **C - 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?

The thesis has a good technical level except for occasional errors. For example, the explanation of heart rate variability (HRV) triangular index is at least unclearly explained, if not wrong. The unit of power spectral density is probably incorrectly stated to be $msec^2/Hz$ in figures on p. 50 and p. 51. In Appendix C, the units are completely missing. I appreciate that the Matlab code is neat, logically organized and sufficiently commented.

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 notations are appropriate and the organization of the thesis is logical and easy to follow. The thesis is sufficiently extensive and I do not see the reason why there are so many blank spaces on the pages which makes it to be 88 pages long. More condensed graphical style would save paper and the reader would not have to turn pages so often. Several paragraphs were difficult to understand (e.g. 2.3.2 and 4.1.5). Illustrative figures would help in these cases. I appreciate that the work is written in English, the language of today's scientific and technical communication. The language level is good except for occasional mistakes in articles and possibly inaccurate vocabulary (e.g. animal "species" vs. "strain", "achieved" vs. "obtained", "suspicion" vs. "assumption", etc.). Graphically, the work makes a good impression and is easy to read except for too small axes labels on p. 34, 50 and 51.

CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

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Selection of sources, citation correctness	**B - very 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 thesis cites a decent number of publications. The student's original work is clearly distinguished from previous work, e.g. the Matlab functions that the student implemented himself (vast majority) vs. functions taken from other sources. My only minor concern is where was the human ECG data for Figure 2.1 obtained?	

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 overall quality of the work is good. For the utilization in scientific analyses, some of the developed algorithms (e.g. R peak detector) would need to be tested against some gold standard such as expert annotations.

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.

Apart from few mistakes and inaccuracies the thesis has a good level and is nice to read. The student has proven good technical skills. Here are some questions for the defense:

1) In paragraph 2.3.1, the equation (2.6) is not clear and does not seem to correspond to its verbal description. What exactly are h, k and M? Supposing h is the histogram counts and M is large enough to comprise all the histogram bins, then HTI = 1 if calculated using the equation.
2) The artifact- and dropout-containing segment of the signal were removed using Bayesian autoregressive changepoint detection (BACD) algorithm applied to interpolated heart rate (HR) signal which is obtained from detected R peaks. In the case of artifacts, false R peak detections are likely. a) If their number is low the HR does not reach the threshold for deemed artifacts and false R peak detections cause inaccuracies in HR estimate. b) Even if the threshold is reached the algorithm does not discard the signal segment unless the threshold is reached for more than 2% of the time. Since the artifacts cause very large deviations from the true HR even when they are infrequent (less than 2%) they may influence the HR estimate. 3) At the level of HR it may be difficult to distinguish between e.g. signal dropout and cardiac arrest. Why were the artifacts and dropouts removed at the level of HR signal and not at an earlier stage of the analysis, e.g. based on some parameters of the raw signal?
3) Explain the biological interpretation of the VLF and pRR10. Can you speculate on why they yield the best classification results? Can you link it to the pathophysiology of epilepsy?

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

Date: **31.5.2022** Signature: