FACULTY
OF INFORMATION
TECHNOLOGY
CTU IN PRAGUE

Supervisor's statement of a final thesis

Supervisor:	Dr. Christian Mandler
Student:	Bc. Eliáš El Frem
Thesis title:	Market Data Anomaly Detection
Branch / specialization:	Knowledge Engineering
Created on:	22 May 2024

Evaluation criteria

1. Fulfillment of the assignment

[1] assignment fulfilled
▸ **[2] assignment fulfilled with minor objections**
[3] assignment fulfilled with major objections
[4] assignment not fulfilled

Overall, the assignment was fulfilled. While some of the partial goals were covered only very briefly (e.g. the summary of the results by Bianchetti and Scaringi lacks details) or not covered at all (e.g. experimenting with different hyperparameters), the main goal to conduct further research on the detection of anomalies was accomplished.

2. Main written part 75 /100 (C)

The overall thematic flow and structure of the thesis is well chosen. The topics covered in the different chapters are related to one another and later chapters are based on the topics covered in earlier chapters. However, some sections lack depth, which, in some cases, leads to inaccuracies (see comment for part 7). In addition, typing errors hamper the readability of the thesis.
Sources are appropriately quoted and a list of all sources is provided.

3. Non-written part, attachments 90 /100 (A)

The code is comprehensible and well structured. Unfortunately, the data used for the analysis was not provided by the student.

4. Evaluation of results, publication outputs and awards 90 /100 (A)

As tAs the experiments were run on real-world data, the results could be applied in practice. As the methods/algorithms used in the thesis have all been published before, the thesis does not include any completely new findings, but this is expected.

5. Activity of the student

- ▸ [1] **excellent activity**
  [2] very good activity
  [3] average activity
  [4] weaker, but still sufficient activity
  [5] insufficient activity

The student met all deadlines and was always well prepared.

6. Self-reliance of the student

- ▸ [1] **excellent self-reliance**
  [2] very good self-reliance
  [3] average self-reliance
  [4] weaker, but still sufficient self-reliance
  [5] insufficient self-reliance

The student was completely self-reliant when it comes to the implementation of the deployed algorithms. In meetings only theoretical topics were discussed.

The overall evaluation 82 /100 (B)

As mentioned above, the overall goal of conducting further research on the detection of anomalies in market data was accomplished. However, most chapters suffer from a lack of detail or inaccuracies. For example, in Section 1.1, multiple algorithms are introduced but very little to no details on the algorithms are provided. The introduction to Isolation Forests mentions scores but does not explain how these scores are obtained. The introduction of SVMs gives an example for a kernel but does not include a formulation of the underlying optimization problem using kernels. The section on Hurst Exponentials does not include information on how the parameter can be interpreted (i.e. are lower or higher values "better"?).
In addition, for most of the algorithms used, it is never mentioned how anomalies/ outliers are defined. In Section 4.5.4 (p. 68), a "threshold" is mentioned for the first time. It appears to be the case that all algorithms used for the experiments rely on a threshold to define anomalies, but this is never discussed.
Even without a formal definition of anomalies, the results in Chapter 4 are comprehensible. This is mostly due to the decision to provide plots for each data set – algorithm combination. Providing the time series plots of the original data with the detected anomalies as well as the reconstructed time series allows the reader to easily connect the reconstruction to the marked outliers. In addition to the plots, the student provides a brief discussion of each plot as well as an overall evaluation of the results for each algorithm. If the algorithms return unfavorable results, the student highlights this and, in most cases, provides a possible explanation for these observations.
To evaluate the performance of the different algorithms, the student used multiple approaches. Two of them (overlaps, Silouhette scores) are based on the financial data sets used for the main part of the experiments. A third one is based on an artificial time series. For this approach, the student created a pseudo-random time series to which he added anomalies. Afterwards, it was checked how many of these anomalies were detected by the considered algorithms. Unfortunately, the student only considered one such artificial

time series. Repeating the experiment with a larger number of pseudo-random time series as well as analyzing the impact of the different parameters used in the time series (base_trend_slope, period_length, anomaly_magnitude, struct_break_magnitude) would have been interesting.

It should be emphasized that some of the algorithms used in the experiments were not used in the original research on which the thesis is based. Even though one of the additional algorithms (Hurst Exponential) proved to be impractical (which was also noted by the student in his conclusion), this highlights that the student did his own literature research on anomaly detection algorithms.

All in all, it is obvious that the student put a lot of effort into the thesis. For example, the experiments were quite extensive as each algorithm was deployed on data for various asset classes and multiple data adjustments (detrending, (relative) differences) were used. However, as mentioned previously, the thesis would have greatly benefited if a little more depth had been added. Overall, the lack of depth as well as the absence of an analysis of the impact of different hyperparameters lead to a deduction from the final grade.

Instructions

Fulfillment of the assignment

Assess whether the submitted FT defines the objectives sufficiently and in line with the assignment; whether the objectives are formulated correctly and fulfilled sufficiently. In the comment, specify the points of the assignment that have not been met, assess the severity, impact, and, if appropriate, also the cause of the deficiencies. If the assignment differs substantially from the standards for the FT or if the student has developed the FT beyond the assignment, describe the way it got reflected on the quality of the assignment's fulfilment and the way it affected your final evaluation.

Main written part

Evaluate whether the extent of the FT is adequate to its content and scope: are all the parts of the FT contentful and necessary? Next, consider whether the submitted FT is actually correct – are there factual errors or inaccuracies?

Evaluate the logical structure of the FT, the thematic flow between chapters and whether the text is comprehensible to the reader. Assess whether the formal notations in the FT are used correctly. Assess the typographic and language aspects of the FT, follow the Dean's Directive No. 52/2021, Art. 3.

Evaluate whether the relevant sources are properly used, quoted and cited. Verify that all quotes are properly distinguished from the results achieved in the FT, thus, that the citation ethics has not been violated and that the citations are complete and in accordance with citation practices and standards. Finally, evaluate whether the software and other copyrighted works have been used in accordance with their license terms.

Non-written part, attachments

Depending on the nature of the FT, comment on the non-written part of the thesis. For example: SW work – the overall quality of the program. Is the technology used (from the development to deployment) suitable and adequate? HW – functional sample. Evaluate the technology and tools used. Research and experimental work – repeatability of the experiment.

Evaluation of results, publication outputs and awards

Depending on the nature of the thesis, estimate whether the thesis results could be deployed in practice; alternatively, evaluate whether the results of the FT extend the already published/known results or whether they bring in completely new findings.

Activity of the student

From your experience with the course of the work on the thesis and its outcome, review the student's activity while working on the thesis, his/her punctuality when meeting the deadlines and whether he/she consulted you as he/she went along and also, whether he/she was well prepared for these consultations.

Self-reliance of the student

From your experience with the course of the work on the thesis and its outcome, assess the student's ability to develop independent creative work.

The overall evaluation

Summarize which of the aspects of the FT affected your grading process the most. The overall grade does not need to be an arithmetic mean (or other value) calculated from the evaluation in the previous criteria. Generally, a well-fulfilled assignment is assessed by grade A.