

Doctoral Programme of Computing and Electrical Engineering
EXTERNAL PRE-EXAMINER'S REPORT ON DOCTORAL THESIS

Kindly complete this report and forward it to the Programme by email to cee.doc.tau@tuni.fi within two (2) months' time.

Candidate's particulars

Name of the candidate: Justyna Skibińska

Title of the thesis: MACHINE LEARNING-AIDED MONITORING AND PREDICTION OF RESPIRATORY AND NEURODEGENERATIVE DISEASES USING WEARABLES

Assessment of thesis

(1) General evaluation of the thesis

Please evaluate all items 1-10 and mark clearly just one box in each item.

	Excellent	Very good	Good	Satisfactory	Sufficient	Insufficient
1. Originality	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Clarity of research questions, objectives and conclusions	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Significance of research contribution	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Technological relevance	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Coherence: does the manuscript comprise a coherent unified entity	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Soundness of research methodology	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Adequacy and completeness of references	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. Logical organization, presentation and language	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. Independent contribution considering also the role in co-authored publications	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. Maturity and critical attitude	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

(2) Report on the thesis (Please use separate sheets, if necessary.)

Please write here a free-format report of 1-2 pages for summarizing your opinion about the scientific value of the work (the most important results and merits of the dissertation) and the discovered shortcomings. Justify the grades awarded to the individual components in the table above, especially if exceptionally high or low grades are suggested. Minor mistakes and stylistic corrections may be communicated directly to the doctoral candidate, but such suggestions should be noted in the statement.

This dissertation aims to frame the usefulness of wearable devices and powerfulness of Machine Learning Algorithms (MLA) into the context of health care support for emergent diseases' detection and rehabilitation. The striking case studies on which the thesis found its original contribute are on data collected during the COVID 19 pandemic emergency and Parkinson Diseases rehabilitation exercises.

The thesis take into account the utility of wearable devices for healthcare remote monitoring to support healthcare services when the care system is not sufficiently developed or does not have enough facilities to

manage emergencies such as the pandemic event COVID 19. In such cases it is shown that introducing IoT-based and wearables devices it is possible to obtain high accuracy in diagnosing patients in the prodromal phase of the disease and in monitoring their symptoms i.e., respiratory rate, heart rate, temperature, etc. The candidate has expertise in the field being co-author of a systematic review of these wearables and their need for supporting healthcare system. The review has been published on Sensors. 2021, <https://doi.org/10.3390/s21175787>.

It is also shown that Wearable devices can be of great help, other than being cheap and available for all in monitoring patients with neurodegenerative diseases, particularly Parkinson's disease (PD). PD's early detection is very important since there is no cure and the treatment is more effective when administered early. Wearable devices can last for many days without charging, provide long time monitoring, and are minimally invasive in the daily activities. The candidate has gained expertise in this field being co-author of a paper where actigraphy sensors suitable for the analysis of sleep disturbance in Parkinson's patients and nocturnal symptoms of Parkinson's disease are used. The paper has been published in the proceeding of ICL-GNSS 2021, June 01–03, Tampere, Finland

Finally, Machine Learning (ML) methodologies are reviewed for the recognition and detection of pandemic event exploiting data collected by wearables devices. Additionally, always using mHealth and eHealth wearable devices, ML approaches are proposed for PD detection exploiting symptoms such as hypomimia, HD, and sleep disorders. Additionally, techniques of EEG analysis based on deep learning methods are discussed, such as SSDA, 1-D CNN, ConvA, LSTM, CNN, BLSTM, DeepSleepNet.

Chapter 4 of the thesis is dedicated to the case study of COVID 19. In this chapter the candidate discuss original ML algorithms applied on data obtained from mHealth and eHealth wearable devices to provide an early stage diagnosis and to discriminate COVID 19 from two different type of Influenza and from Control.

Similarly, Chapter 5 is reporting mHealth dedicated solutions for Parkinson's Detection using a numerical analysis of the changes in facial emotional expressions over time. Face expression recognition (FEC) techniques based on neural networks were used to detect frame by frame changes.

It clearly appears that the thesis' work is scientifically new, scientifically significant and of practical uses. All over the manuscript the objectives are coherently reported to support and discuss a unique scientific goal: the application of ML to mHealth and eHealth signals obtained from wearable devices.

Research questions are faces with mastery and appropriateness and the proposed research methods are proved to be successfully accurate and of practical application showing the ability of the candidate to manage them, and her knowledge of the relevant scientific literature. As for the publications reported in the thesis it clearly appear the candidate's independent contribution in the co-authored publications and the planning and implementation of research, being the first author most of the time.

The data exploited for the case study are well known benchmarks assuring the repeatability of the proposed experimentation on more huge datasets also obtained from different sources

The writing style and presentation is a little confusing, leaving to the reader the effort to figure out the entire work as a whole. The summaries of the thesis chapters miss a coordinated vision that give to the reader the flavor of the objectives and results. This can be improved revising them and producing a more coordinated and general summary rather than detailed results.

- Coherence: Does the manuscript comprise a coherent, unified entity
- Clarity of the research questions and objectives
- Mastery of the research method(s)
- Quality, extent and relevance of research data
- Knowledge of relevant scientific literature
- The doctoral candidate's independent contribution, for example, to co-authored publications and the planning and implementation of research
- The doctoral candidate's scientific maturity and critical thinking skills
- Writing style and presentation

(3) Recommendation on thesis pre-examination result

As your overall assessment, place the thesis in one of the following categories by a tick (x) mark.

1. I recommend the permission to publish the thesis.
(Pre-examiner is allowed to suggest minor amendments and minor technical revisions.)
2. I don't recommend the permission to publish the thesis for the reasons set out in my detailed report.

(4) Recommendation for the grade

The faculty council approves and evaluates the dissertation based on the written statements of the opponents, the proposed grade of the possible evaluation board, the pre-examination statements and other written comments.

Doctoral dissertations are graded on a scale of *approved with distinction*, *approved*, and *failed*. For justified reasons, a particularly distinguished dissertation can be awarded the grade 'Approved with distinction'.

My recommendation for the grade:

Approved with distinction

Approved

Failed

Is the dissertation in the international top 10-15% of all dissertations in the field?

Yes

No

Date: 03/08/2023

Name: Anna Esposito



Signature: