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Jury Member Report – Doctor of Philosophy thesis.

Name of Candidate: Maame Gyamfua Asante-Mensah

PhD Program: Computational and Data Science and Engineering

Title of Thesis: Automatic noise and artifacts removal from biomedical signals and images using tensor completion

Supervisor: Professor Andrzej Cichocki

Name of the Reviewer:

I confirm the absence of any conflict of interest (Alternatively, Reviewer can formulate a possible conflict)	**Date: 16-05-2023**

The purpose of this report is to obtain an independent review from the members of PhD defense Jury before the thesis defense. The members of PhD defense Jury are asked to submit signed copy of the report at least 30 days prior the thesis defense. The Reviewers are asked to bring a copy of the completed report to the thesis defense and to discuss the contents of each report with each other before the thesis defense.

If the reviewers have any queries about the thesis which they wish to raise in advance, please contact the Chair of the Jury.

Reviewer's Report

Reviewers report should contain the following items:

- Brief evaluation of the thesis quality and overall structure of the dissertation.
- The relevance of the topic of dissertation work to its actual content
- The relevance of the methods used in the dissertation
- The scientific significance of the results obtained and their compliance with the international level and current state of the art
- The relevance of the obtained results to applications (if applicable)
- The quality of publications
- The summary of issues to be addressed before/during the thesis defense

General Comment:

In this thesis, the author explores the utilization of low-rank tensor decomposition techniques to eliminate noise and artifacts from biomedical signals and neuroimages. The problem is formulated as a constrained optimization problem, which is addressed by employing a modified alternating direction method of multipliers (ADMM) with the objective of minimizing the tensor nuclear norm while imposing sparsity or smoothness constraints. The author compares different strategies for block Hankel folding and tensorization techniques to convert low-order tensors into higher order block Hankel tensors. This conversion is performed prior to applying tensor completion using tensor train and tensor ring low-rank decompositions. The incorporation of the Hankelization step ensures the low-rank property of the incomplete data and enhances the accuracy of reconstructing images and signals corrupted by significant amounts of noise. Furthermore, the author investigates tensor cross-approximation models and associated algorithms to efficiently process corrupted noisy data. These models aim to achieve fast and effective processing of the corrupted data.

The thesis introduces three primary contributions, including exploiting a sparse representation for tensor ring cores using dictionary learning, computing modified CUR approximations with smoothing constraints for underlying data tensor, and the development of an algorithm for motion artifacts in diffusion-weighted MRI images. The extensive computer simulations performed using all three strategies demonstrate the effectiveness and superiority of the proposed methods.

The relevance of the topic of dissertation work to the actual content is appropriate and accurately presented. The author effectively justifies the importance of noise removal and artifact correction in biomedical signals and neuroimages and provides adequate background information. Additionally, the manuscript shows relevance in applying low-rank tensor decomposition techniques to this problem.

The author has published extensively in recognized peer-reviewed journals, including Machine Learning: Science and Technology, IEEE Access, and IEEE International Conference on Data Mining Workshops (ICDMW).

The methods used in the dissertation are well-suited to remove a huge amount of noise and address various artifacts in MRI and EEG signals. The author investigates various decomposition techniques, which are appropriate and effectively applied to this research problem. Furthermore, the use of convolutional neural networks as a significant Hankelization step in tensorization is a novel approach and provides an interesting contribution. The scientific significance of the results obtained and their compliance with the international level and current state of the art is considerable.

In summary, the author presents an extensive study that applies low-rank tensor decomposition techniques to address noise and artifacts in biomedical signals and neuroimages. The manuscript provides a clear introduction, methodology, results, and conclusions that are well-supported with convincing examples.

However, some issues need to be addressed before/during the thesis defense. The author needs to provide more detail on the limitations of the proposed approaches and their applicability in real-world scenarios. In addition, the author needs to provide more details on the experimental setup and procedures, especially for the smoothness details in section 5.3.2. Furthermore, it is important for the author to ensure that the thesis is well-organized and structured in a way that enhances the flow of ideas for readers. There are numerous grammatical errors throughout the document. Some more detailed comments are as follows:

1. It may be more reader-friendly if the motivation of sparse representation of tensor ring core can be explained in details. Is there any physical background for such a representation?

2. In chapter 6, t-SVD based low rank approximation is used to MRI Motion Artifact Reconstruction. Why do you prefer this decomposition? Compared with some tensor networks, why do you choose t-SVD for it?
3. In chapter 6, only a visual reconstruction is shown. It would be more convincing to give performance in term of some statistical measures.
4. In fact, there are a lot of compressed sensing MRI methods, which can be added to make the experimental results more convincing. For example, we have a similar paper published 3 year ago: "Smooth Robust Tensor Principal Component Analysis for Compressed Sensing of Dynamic MRI," Pattern Recognition, vol. 102, no. 107252, 2020.

Provisional Recommendation

☐ *I recommend that the candidate should defend the thesis by means of a formal thesis defense*

☒ *I recommend that the candidate should defend the thesis by means of a formal thesis defense only after appropriate changes would be introduced in candidate's thesis according to the recommendations of the present report*

☐ *The thesis is not acceptable and I recommend that the candidate be exempt from the formal thesis defense*