Ing. Ondřej Klempíř

ANALYSIS OF NEURAL ACTIVITY IN THE HUMAN BASAL GANGLIA: FROM MICRO TO MACRO

Review of the Ph.D. dissertation

The dissertation of Ing. Ondřej Klempíř in the Ph.D. study programme *Biomedical and Clinical Technology* is devoted to a very important topic related to the deep brain stimulation (DBS) of the human basal ganglia of patients with motion disorders. It is devoted to a complex task of the analysis of neurophysiological recordings to help with the teraphy of patients with dystonia or Parkinson's disease. Topics of the dissertation include detail mathematical studies of these processes, statistical analysis of novel biomarkers and the description of the pathophysiological DBS mechanisms to contribute to understanding of this area with a wide importance in the clinical practise.

The dissertation describes in its initial part the interdisciplinary background related to disorders of basal ganglia functions and measuring of single neuronal activity. The methodological part includes notes to spike detection, processing of neural signals, data evaluation and identification of microrecording artifacts. Ing. Ondřej Klempíř proved in this part his deep knowledge of the whole research area and mathematical methods used for data processing including principles of signal processing, digital filtering, and related models description.

The main part of dissertation of Ing. Ondřej Klempíř presents the application of results in the clinical neurophysiology including brain mapping. It is necessary to appreciate the presentation of newest methods of the deep learning and multilayer neural networks as well. Both detail description of motion disorders, and the methodology related to associated problems include references to selected sources. Ing. Ondřej Klempíř has proved in these sections of the dissertation a very good knowledge of methods used in this research area and his ability to choose appropriate methods and algorithms for modern methods of neuroinformatics.

The own research work of Ing. Ondřej Klempíř combines the critical review, theoretical analysis and verification of selected methods important for brain and motion data processing. The author presents deep analysis of methods and evaluation criteria. It is necessary to appreciate the study of motion features related to problems of dystonia and the Parkinson's disease and presentation of results both in tabular and graphical forms. Comments to the proposed methodology of neurological data processing form further important results of the present dissertation with the use in the clinical practise.

A special attention is paid to the classification of microelectrode artifacts by means of convolutional neural networks and software tools for automatic spike detection. It is assumed that the present research and results of the dissertation will contribute to a better understanding of mechanisms of the deep brain stimulation.

I have the following comments and notes to the dissertation:

- Page 38, Section 5.2 Data acquisition should be described into more details and conditions of measurement presented. Why the sampling frequency of 20 kHz was selected? Which noise components were present?

- Page 39, Section 5.1: The dissertation should contain more details related to mathematical background of signal processing. Which relation was used for digital filtering? Why IIR and not FIR filters were used? In which way cut off frequencies were selected? The selection of these frequencies is different here and on page 32.

- Page 49, Section 6.1.2: The discrete Fourier transform and wavelet transform for spectral components detection and evaluation mentioned here should be described into more details. Why continuous and not discrete wavelet transform is suggested? And why the Morlet wavelet function is suggested? Were further wavelet functions used as well?

- Page 52, Section 6.1.5: The F1 score should be defined

- Page 53, Section 6.1.6: The methodology of the deep learning and convolutional neural networks used should be described into more details. How many layers were used? And which parameters selected? How long the training process was?

- Page 81, Section 8.3.6: How the brain mapping contributed to the main topic of the dissertation? Which interpolation methodology was applied?

- Page 87, Section 8.5 Discussion: The own contribution to the methodology should be emphasized here. Is the set of programms for data analysis available (on the web page of the author)? The comparison with other methods should be presented here as well. Which is the future direction of the research in this area? It should be discussed here as well.

The dissertation is well organized and it consists both of the clear presentation of all methods used to contribute to the analysis of given problems and own research work. The formal part of the dissertation is very good and it is necessary to appreciate the list of tables, list of figures, and list of abbreviations as well. It is necessary to appreciate a very extensive list of references including links to latest papers as well.

The dissertation of Ing. Ondřej Klempíř is both from the research and formal points of view on a very good level and it summarizes topics related to deep brain stimultation using modern mathematical methods. The list of own publications of Ing. Ondřej Klempíř includes impacted journals and both international and local conference proceedings reviewed by independent reviewers already.

The dissertation of Ing. Ondřej Klempíř forms a contribution to the important area of neurological data processing. Methodology proposed, very deep and precise theoretical analysis, and results achieved are described in the dissertation in a very good way and they form a basis of further research in this area.

Owing to facts presented above it is possible to confirm that the research work of Ing. Ondřej Klempíř and his dissertation correspond with the generally accepted international demands and it is possible to recommend its defence.

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