

---

Doctoral Thesis Abstract

**Designing and developing a system of processing  
and analysis of medical signals, monitoring the intensity of pain**

**Author:** mgr inż. Aleksandra Badura

**Supervisor:** prof. dr hab. inż. Ewa Piętka

The dissertation presents the method for pain occurrence recognition during manual therapy based on the analysis of selected biomedical signals. The work includes a description of the measurement platform that synchronizes data recorded by wireless devices placed on the patient's body. Then, the data acquisition process is presented. The study was performed during arm and neck fascial therapy and temporomandibular joint therapy. Additionally, an experimental database related to thermal stimulation was used. Each dataset differs in data labeling method. A new approach to reporting pain intensity using a hand dynamometer is introduced in response to the physiotherapy requirements.

Then, two classification methods for pain recognition are described. The first aims to find distinctive modalities and their features: the adaptive boosting (AdaBoost) model was trained with fascial therapy data and classified separated data frames. The deep model using long short-term memory (LSTM) is the second branch of the analysis. An effective model detecting pain occurrence moments was obtained for the temporomandibular joint therapy data. Next, the classification accuracy was compared to the attempt where experimental data stood for the training set. High results directed further analysis into integrating thermal stimulation data patterns and clinical data. Hence, the final model obtained with the transfer learning method performed best in pain recognition during manual therapy.

The last stage was statistical analysis. Applying linear mixed effects models showed that the determined data representation significantly distinguishes pain and no pain states. The effect of the pain stimulus type on determined features was noted, which showed differences in physiological reactions to thermal and mechanical stimuli. Additionally, the analysis showed no significant differences between the pain reactions in healthy and suffering subjects during temporomandibular joint therapy.

**Keywords:** automated pain assessment, physiological signals, physiotherapy, manual therapy, transfer learning

---