Bmed-H
e-ISSN: 2582-7405
Transaction on Biomedical Engineering Applications and Healthcare
Vol-2 Issue-2, October 2021

Biomedical Signal Processing: Understanding Its Importance and Several Fundamental Steps

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Abstract

The study has depicted the analysed interpretation of importance of biomedical signal processing in medical aspects. Secondary data collection method and thematic data analysis process have been used in this study on the basis of peer reviewed journals that make the study more reliable for the readers. Basic concept of biomedical signal processing has been discussed over here with the diagnosis capability and extraction signal information of biomedical signal processing system to detect the physiological disorders. Challenges and opportunities of biomedical signal processing have been focused in this study to evaluate the impact of it in medical ground. Various applications of biomedical signals have been highlighted in this study including ECG, EEG, fEEG and many more devices. Advance technological implication in biomedical signal processing has been considered in this study highlighting the mechanical composition of ECG machine. Some recommendations of modification of biomedical signal processing system has been considered in this study such as increasing of controlling capability of diverse noise signals that can reduce power line interference.

Keywords

Biomedical Signal Processing, ECG Machine, Physiological Disorders.

INTRODUCTION

Pre-processed physiological signals and extracting the insights of the signals have been considered as the biomedical signal processing. Identification of patterns and trends of signals helps to measure the neural activities, cardiac rhythms, muscle movements and other physiological activities. Advanced technological implication in biomedical signal processing introduces the EEG, ECG, EMG, EOG GR and MRI that determine the significant physiological disorder [1]. The design of biomedical signals ensures the noise free accurate signal model to analyse the components of physiological activities to extract reasons for dysfunction. Prediction of pathological and functional events in physiological activities in the brain, heart or muscle can be driven by the biomedical signal processing. Physiological and clinical information retrieval becomes easier with the utilisation of biomedical processing signals. Digitised biomedical signals help to derive only filtered data and relevant parameters of physiological needs.

Biomedical processing signals impact the diagnosis process of physiological dysfunction along with patient monitoring and biomedical research that is a symbol of progression in the medical aspect of different countries. Equalisers, reverbs and dynamics determine the signal processors in biomedical consequences [2]. The main objective of biomedical signal processing is to measure phenomena information to interpret the data relevant to the physiological needs that can be used in the system processing. Electromagnetic sources of the body are the main source of biomedical signals orientation. Audio compression and data acquisition are the basic functions of biomedical signal processing. Health care applications are mostly influenced by signal processing in the biomedical field considering pre and post processing analysis, classifications of signals along with application of analysed signal processing.

There are different types of signals that can be helped to retrieve phenomenon data on the basis of physiological parameters such as continuous time and discrete time signals, deterministic and non-deterministic signals along with even and odd signals. Periodic and aperiodic signals, energy and power signals, real and imaginary signals can also be categorised in the classifications of signals. Three types of electrodes are used in the biomedical signal processing that helps to identify biological dysfunctions [3]. In overall consecutive perceptions of biomedical signal processing are the significant initiatives taken by advanced medicals that ensure the health betterment.

MATERIALS AND METHODS

Research approach

Research approach is the process to plan research execution considering the data collection procedure, analysis and interpretation depending on the broad assumption relevant to the subject of the study. After evaluating the importance of the study, an inductive research approach has been selected by the writer to conduct the study in a justified way. Inductive research approach helps to retrieve data information from general overview and summarised in a specific conclusion [4]. General observation about the topic of biomedical signal processing has been justifiably interpreted here with the inductive research approach.

Research design

Blueprints of scientific justification can be considered as the research design that helps a study to meet the goal of research. There are two types of research design, quantitative and qualitative [5]. In this study qualitative research design has been chosen by the writer to execute the study. Non numerical data information has been collected in qualitative research design to interpret the justification of the study. Qualitative research design helps to understand the concepts, opinions and importance of the subject of the study to meet the goal of the study.

Research type

Research types help to classify research methods considering distinctive properties and data collection methods. Following the study needs the writer of the study has selected the secondary research type to evaluate the impact of biomedical signal processing in the healthcare industry prioritising the realistic observation. Existing information is the basic concept of secondary research types that helps to gather data information from already optimised data.

Data collection procedure

Data collection procedure is the most intensive method to collect data in favour of subject justification of the study. There are two types of data collection procedures that are mostly used to signify the study, one is primary data collection procedure and another one is secondary data collection method [6]. In this study a secondary data collection procedure has been chosen by the writer to justify the study with informative justifications. Peer reviewed journals are used for the secondary data collection of the study. The secondary collected data are more reliable and authentic that enhances the quality of the study. Budget friendly and time saving features of secondary collected data helps to reach the study goal in a shorter time of period. Biomedical signal processing and its impacts on physiological dysfunctions identification can be interpreted with the secondary collected data.

Data analysis methods

Depending on the secondary collected data thematic data analysis has been used in this study to interpret the collected data to justify the subject of the study. Thematic interpretation of collected data has the scope to consider realistic observation of the writer to signify the study. Flexibility and independent thought expressing approach of the thematic data analysis process increases the quality of the study. Themes are developed on the basis of peer reviewed journals that enhance the reliability and validity of the study which creates a trustworthy approach towards the readers [7]. Cost effective and time saving manner of thematic data analysis procedure helps to maintain the authentication and ethical significance of the study. For the betterment of the study secondary data collection method has been included and primary data collection method has been excluded from the study.

Data sources

Peer reviewed journals published after the year of 2019 have been used as data sources for secondary data collection methods. Existing information based peer reviewed journals are more effective to justify the study in a short period of time. The journals also increased the authentication of the study that enhanced the quality of the study with informative justifications to the subject of the study.

Choice of topic

Advancement of the medical field has been driven by the biomedical signal processing considering the progression of medical aspects of different countries. The aim of the study is to evaluate the strength of biomedical signal processing to diagnose physiological dysfunction to cure it. The study has a significant purpose to understand the concept of biomedical signal processing including advantages and disadvantages along with different techniques.

RESULTS AND DISCUSSIONS

Results

Evaluation of trends of biomedical signal processing

Depending on the increased demand of biomedical signal processing in the medical field most of the developed countries are adopting the biomedical signal processing trends. Statistical interpretation has highlighted that the trend of biomedical signal processing increased day by day and improved the diagnosis and monitoring capability of medical treatment. Several fundamental steps and techniques are used in this process to identify the physiological dysfunctions of human bodies. Electroencephalogram or EEG is one of the most influential tools used in the diagnosis of cardiac disorders or muscle movement misbalancing along with abnormal neural activities [8]. ECG is another initial cardiac dysfunction identification method under biomedical signal processing that helps to classify the signals along with analysing the signal to take preventive measures. Clinical information depending on the biomedical signals helps to better the physiological status of a human body.

Considering machine learning with the implication of artificial intelligence has highlighted the application of biomedical signal processing that enhances the trending approach of this procedure. Intelligent solutions of diagnosis issues can be resolved with the implication of biomedical signal processing in the healthcare industry. Image guided navigation system is an example of a modern trend of biomedical signal processing that helps to analyse the proper procedure of various surgical operations [9]. Tomography has considered the 3D bronchial tree model under biomedical signal processing that obtained the current bronchoscope to detect the accurate disorders. The heart disease detection test using biomedical signal processing provides 90.75% accuracy in result along with assertive detection of heart murmurs. EEG process of identification of physiological

dysfunction considering the machine learning technique called genetic algorithms and logistics regression that helps to recognize cognitive dysfunctional structures.

Wavelet transformation is another modern trend of biomedical signal processing methods in the current medical era that determines the decomposition of data, smoothing data including feature extraction and image segmentation. 2D maps are also considered in the modern trend of biomedical signal processing that ensures the noise free influence with dynamic approach. Fetal echocardiogram is an invasive step of biomedical signal processing that predicts the potential risk factors including infections of mother and fetal and enhances the probability of hazard free delivery [10]. Abdominal abnormalities of the mother can be identified with the implication of an advanced trend of biomedical signal processing.

Implication of time flight sensors in the imaging scanning programmers of biomedical signals helps to minimise the error facts in the results that enhance the clinical treatment quality. Musculoskeletal radiography under biomedical signal processing determines the musculoskeletal abnormalities using a multi-scale convolution neural network combined with graph convolution network. Identification of pathogenic microbes and toxins has also been focused by the biomedical signals to detect contaminated food reaction in the body considering food borne diseases [11]. Prioritising the consecutive perceptions of modern trends of biomedical signal processing, advanced technological implications plays a vital role in medical based progression of developed countries.

Challenges and opportunities of biomedical signal processing

The entire biomedical signal process is dependent on machine learning and artificial intelligence focusing on the digitalisation of the application in medical circumstances. Identifications of physiological abnormalities including cardiac, neuro and muscular dysfunctions are the basic principles of biomedical signal processing. However, various design errors in the execution of biomedical signal processing can create challenges in medical aspects. Low signal noise ratio is the most crucial challenge in biomedical signal processing fields that fails to optimise accurate results regarding physiological disorders. Non-stationary and non-linearity properties of bio signals affect the data information retrieved from the signal processing that creates various errors in result [12]. Diversity in noise sensors in biomedical signals is overlapping the noise and artefacts of interpreted and analysed results. Proper diagnosis of physiological disorders can be hampered by the false alarms and significant errors. Medical treatments can be misled with the false assessment of disease.

Implications of external devices in traditional signal processing also create obstacles to indicate proper biomedical signals in medical consideration. Filtering techniques of biomedical signal processing can create hazardous chaos in obtaining insights of physiological dysfunctional activities. Lack of optimization in biomedical signals processing is also being unable to identify accurate results regarding physiological disorders. Big data analysis considering biomedical applications sometimes fails to maintain the errorless identification of the characteristics of the biomedical signal processing [13]. On the other hand, regulatory affairs are maintained by the implications of biomedical signal processing in medical consequences. Cardiovascular med-tech has been driven and controlled by the interference of biomedical signal processing.

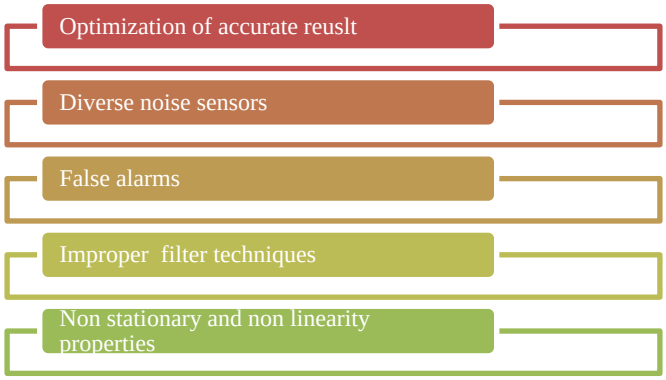

Figure 1: Challenges of biomedical signal processing

Applications of diagnostic and therapeutic instruments along with devices have been considered in the biomedical signals that ensures the advanced curable aspects of physiological disorders. Quick and instant nano based drug delivery accelerates the treatment procedure in favour of patients. Various pharmaceutical innovations under biomedical signals have positively impacted the medical progression including diagnosis and treatment aspects. Implications of regenerative technologies help to accelerate the identification procedure of physiological abnormalities that ensures the increased rate of cure of disease. Long term effective approach of biomedical signal processing increases the demand of this technology considering cost saving aspects [14]. Prioritising the communicative feature of biomedical signal processing, the process indulges the convection of information with less noise, distortion and interference.

Real time monitoring is another effective advantage of biomedical signal processing that helps to manage chronic diseases along with earlier detection of health related certain events such as heart attacks and strokes. Therefore prevention treatment can be considered in medical aspects including enforcing earlier diagnosis of diseases. Specialisation and specifications of physiological disorders especially the cardiac, neuro and muscular abnormalities focusing on the biomedical signal processing have led the medical development in progressing nations [15]. Overall evaluation of biomedical signal processing pros and cons continuous improvisation of biomedical signal processing accelerates the improvement of medical conditions.

Influential impact of biomedical signal processing on pharmaceutical industry

Biomedical signal processing is an extracting method to obtain information on the basis of clinical and pharmaceutically relevant diagnosis. Electric, mechanical and chemical signals have highlighted the biomedical origins of physiological disorders [16]. Improving medical diagnosis is the main purpose of biomedical signal processing. Brain computer interface is the most influential impact of the biomedical signal processing that plays an important role in the implication of clinical efficiency in treatment. Treatment for different able persons can be evaluated with the implication of signal processing of biomedical. Time domain in prediction of disorders through biomedical signal based health monitoring also achieves a pharmaceutical impact in the medical aspect. First and second derivative detection of physiological dysfunctions have been impacted with the biomedical signal processing. Imaging sensors under biomedical signals are the most affecting pharmaceutical beneficial concept of biomedical signal processing.

Restoration of the original image of living things is another positive implication of biomedical signal processing. Following a few steps biomedical signal processing systems can acquire biomedical information using sensors and after that pre-processing can be done with the information. Filtering and featuring characteristics of biomedical signal processing helps to maintain the conveying capability of signals to prevent disorders [17]. Pharmaceutical companies also implicate the effective features of biomedical signals in machinery innovation for clinical and physiological diagnosis. Combination of biomedical signals and imaging procedures reflects the medical development on a large scale with the improvisation of the pharmaceutical industry. For example, ECG machines can be considered as a revolutionary enactment of a biomedical signal processing system that enhances the probability of faster initial diagnosis of cardiac disorders. Digital filters are the basic composition of ECG machines under biomedical signal processing that are formulated with the algorithmic conception to identify the heart rhythms.

The IIR filter in ECG machines acts as a recursive filter that helps to get the feedback of the biomedical signals. On the other hand, FIR filters help to crop the impulsive response from multiple responses considering generation of biomedical signals. RLS algorithms are used in the ECG machine followed by the biomedical signal processing. Notch filters help to eliminate the power line interference from the ECG signals with a specific frequency. The overall impact of ECG composition has been highlighted in the preliminary identification of cardiac dysfunctions to prevent severe uncertain events in the heart. Other devices such as glucose monitor, EHR, EEG that have been used in the clinical diagnosis also accelerate the enactment of biomedical signal processing in medicine along with the pharmaceutical field [18]. Advanced technological implication in machine learning considering biomedical signal processing in medical aspects increases the probability of curable treatment that is a significant symbol of medical progression.

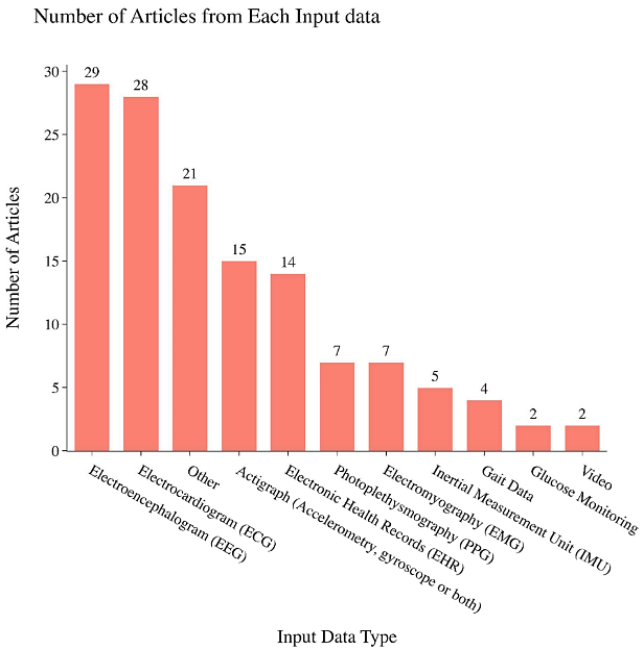

Figure 2: Application of biomedical signal processing

It also helps to understand the importance of biomedical signal processing in medical consequences. Biomedical signal processing involves signal acquisition that focuses on analysing and accessing signals from stored information. Signal visualization and annotation is another way to retrieve data as required considering time frequency domain. Coding technique also has been used in signals visualization. Artefact removal and signal filtering are used in biomedical signal processing to avoid power line interference and better the signals with a noisable hazard free approach [19]. Feature extractions are the main concern of biomedical signal processing that ensures the different degree of severity of physiological disorders. Congestive severity identification of diseases helps to take precautions along with preventive measures to avoid unpleasant complications in the health aspect that creates a revolutionary development in the biomedical field.

Discussion

Biomedical signal processing impact on the medical industry has a significant effect that has been evaluated in the results of the study. The basic concept of the study has referred to generating signals and extracting information from physiological activities. Identifications of physiological disorders can be analysed with the implication of biomedical signal processing. Different trends of biomedical signal processing have been interpreted as the advancement of biomedical signal processing to improve diagnosis and monitoring capability of the system. Implications of EEG, fEEG, time flight are the most influential impacts of biomedical signal processing systems. Challenges faced by the biomedical signal processing also have been focused in

this study to evaluate the strength of the study. Improper filtering techniques can create hazardous effects on the medical ground along with lack of optimization also generate errors in accurate result generation.

Acquisition of big data can fail to maintain the accuracy of diagnostic results that affect the clinical recognition of physiological abnormalities. Beside this, real time monitoring also can increase the efficiency of biomedical signal processing. Cardiovascular disease can be identified with the implication of initial indicating signals of biomedical that helps to avoid sudden cardiac arrest. Pharmaceutical industry also has been benefited with the enactment of biomedical signal processing that encourages the diagnosis improvement. Entire composition of the ECG machine to detect initial dysfunctions of the heart is an example of advanced technological implication of biomedical signal processing. Fusion of imaging and signals considering biomedical signal processing also has been discussed over here to depict the efficiency of biomedical signal processing in detecting different organ disabilities. Brain computer signals have also been considered in this discussion to highlight the effective rate of biomedical signal processing.

2D maps, 3D bronchial tree models also have been focused here to describe the impact of biomedical signals to diagnose physiological disorders. 90.75% of accuracy has been found in the heart disease identification using biomedical signal processing [20]. Musculoskeletal radiography is a most influential diagnostic tool of biomedical signal processing that helps to identify the musculoskeletal abnormalities. Detection of pathogenic microbes considering food borne disease is also a significant characteristic of biomedical signal processing. Fetal echocardiogram is an advanced trend of biomedical signal processing that helps to prevent risk potential of infections in mother and in the fetal. Genetic algorithms and logistic regression of machine learning also has been driven by biomedical signal processing. Cardio, neuro and muscular dysfunctions can be detected with a faster approach of biomedical signal identification. Non-stationary and non-linearity properties of biomedical signal processing can affect the clinical information with devastating errors.

False alarm and unauthenticated customization can be a warning enactment in medical treatment considering biomedical signal processing. Interpretation of information data retrieved from biomedical signals can be hampered with the impact of diverse noise sensors. Cardiovascular medical technology also has been controlled by the implication of biomedical signal processing. Diagnostics tools and therapeutic instruments following the biomedical signal processing are bringing revolutionary development in the medical field. Chronic disease signals using biomedical signal processing systems help to take preventive measures to avoid associated risks regarding health. Electrical, mechanical and chemical signals depending on the electrode's components are used in biomedical signal generation to identify potential signs of physiological disorders.

Different able individuals are also benefited with the advanced application of biomedical signal processing in detecting neural abnormalities in the brain. Different severity degrees of diseases can be identified with the effectiveness of biomedical signal processing that helps to plan proper clinical treatment to prevent or cure the dysfunction of health. Following several fundamental steps of biomedical signal processing have helped to identify physiological dysfunctions along with deriving insights of signals to implicate proper clinical curative initiative focusing on the diagnosis significance. The discussion has to some extent justified the evaluation of importance of biomedical signal processing in the medical field.

CONCLUSION

The study has focused on the different steps of biomedical signal processing to analyse the importance of it in the medical aspect. Secondary data collection method has been selected in this study followed by quantitative research design. Depending on secondary collected data, thematic data analysis has been used in this study to meet the goal of the study with informative justification. Peer reviewed journals are used as a data source in this study to make the study more reliable and validated. Thematic interpretation of the data in this study has been focused on the realistic observation relevant to the subject of the study that highlights the impact of biomedical signal processing on the medical field. The study has depicted the basic principles and objectives of biomedical signal processing such as generation of the physiological dysfunction signals to extract insights of signals to prevent and cure the disorders.

Evaluation of the impact of the biomedical signal processing in the medical aspect has been conducted in this study to meet the goal of the study. Pros and cons of both consecutive scenarios have been highlighted in this study to signify the subject of the study. Fundamental steps of biomedical signal processing following the trends of medical development have been briefly discussed over here. Machine learning considering electrical, chemical and mechanical signals are used in this biomedical signal processing system that helps to diagnose physiological abnormalities in a faster approach. Different biomedical signals such as EEG, ECG, fEEG and MRI have been highlighted in this study to reflect the impact of biomedical signal processing including depicting the composition and functional execution of ECG machines.

RECOMMENDATIONS

Prioritizing the digital filter implications in ECG machines, biomedical signal processing can detect initial dysfunctions of cardiac activities to prevent certain unpleasant events and offer instant solutions in the medical aspect. Improvement of diverse noise signals in biomedical signal processing can be a more modified version of

biomedical signal invasion. Proper designing and customization also can help to reduce errors in results that enhance accuracy of results and ensure clinical initiatives based on diagnosis information. Composition of digital filters should be more efficient to eliminate power line interference to predict initially along with chronic physiological dysfunction in a faster approach. Considering all consequences of biomedical signal processing it has been highlighted that the biomedical signal processing system has a significant positive impact on the medical aspect.

REFERENCES

[1] Shuvo, Ikra Iftekhar, Aastha Shah, and Canan Dagdeviren. "Electronic textile sensors for decoding vital body signals: State-of-the-art review on characterizations and recommendations." *Advanced Intelligent Systems* 4.4 (2022): 2100223.

[2] Hawley, Scott H., Benjamin Colburn, and Stylianos I. Mimilakis. "SignalTrain: Profiling audio compressors with deep neural networks." *arXiv preprint arXiv:1905.11928* (2019).

[3] Swapna, Mudrakola, et al. "Bio-signals in medical applications and challenges using artificial intelligence." *Journal of Sensor and Actuator Networks* 11.1 (2022): 17.

[4] Linneberg, Mai Skjott, and Steffen Korsgaard. "Coding qualitative data: A synthesis guiding the novice." *Qualitative research journal* 19.3 (2019): 259-270.

[5] Rashid, Yasir, et al. "Case study method: A step-by-step guide for business researchers." *International journal of qualitative methods* 18 (2019): 1609406919862424.

[6] Nayak, M. S. D. P., and K. A. Narayan. "Strengths and weaknesses of online surveys." *Technology* 6.7 (2019): 0837-2405053138.

[7] Rose, Jeff, and Corey W. Johnson. "Contextualizing reliability and validity in qualitative research: Toward more rigorous and trustworthy qualitative social science in leisure research." *Journal of leisure research* 51.4 (2020): 432-451.

[8] Fingelkurts, Alexander A., and Andrew A. Fingelkurts. "Quantitative Electroencephalogram (qEEG) as a Natural and Non-Invasive Window into Living Brain and Mind in the Functional Continuum of Healthy and Pathological Conditions." *Applied Sciences* 12.19 (2022): 9560.

[9] Zaffino, Paolo, et al. "A review on advances in intra-operative imaging for surgery and therapy: imagining the operating room of the future." *Annals of Biomedical Engineering* 48 (2020): 2171-2191.

[10] Vo, Khuong, et al. "An efficient and robust deep learning method with 1-D octave convolution to extract fetal electrocardiogram." *Sensors* 20.13 (2020): 3757.

[11] Wu, Guowei, et al. "Current Status and Future Trends in Removal, Control, and Mitigation of Algae Food Safety Risks for Human Consumption." *Molecules* 27.19 (2022): 6633.

[12] Jelinek, Herbert F., et al. "The effect of ankle support on lower limb kinematics during the Y-balance test using non-linear dynamic measures." *Frontiers in Physiology* 10 (2019): 935.

[13] Elworth, RA Leo, et al. "To petabytes and beyond: recent advances in probabilistic and signal processing algorithms and their application to metagenomics." *Nucleic acids research* 48.10 (2020): 5217-5234.

[14] Nigusse, Abreha Bayrau, et al. "Wearable smart textiles for long-term electrocardiography monitoring—A review." *Sensors* 21.12 (2021): 4174.

[15] Poller, Wolfgang, et al. "Innate Immunity in Cardiovascular Diseases—Identification of Novel Molecular Players and Targets." *Journal of Clinical Medicine* 12.1 (2023): 335.

[16] Xu, Qianqian, et al. "Construction of bio-piezoelectric platforms: From structures and synthesis to applications." *Advanced Materials* 33.27 (2021): 2008452.

[17] Palumbo, Arrigo, et al. "Biopotential signal monitoring systems in rehabilitation: A review." *Sensors* 21.21 (2021): 7172.

[18] Will. K. W. et al. A Systematic Review of Time Series Classification Techniques Used in Biomedical Applications. *MDPI*. 2022. https://www.mdpi.com/1424-8220/22/20/8016/htm.

[19] Márquez-Figueroa, Sandra, Yuriy S. Shmaliy, and Oscar Ibarra-Manzano. "Optimal extraction of EMG signal envelope and artifacts removal assuming colored measurement noise." *Biomedical Signal Processing and Control* 57 (2020): 101679.

[20] Wasimuddin, Muhammad, et al. "Multiclass ECG signal analysis using global average-based 2-D convolutional neural network modeling." *Electronics* 10.2 (2021): 170.