Journal of Advanced Zoology

ISSN: 0253-7214

*Volume **44** Special Issue**-2 Year 2023** Page **5279:5286***

Biomedical Signal Processing and Healthcare Applications: Innovations and Challenges

Dr. Mandeep kaur
Designation: Assistant Professor Department: Electronics and Communication Engineering College Full name : Department of Electronics and Communication Engineering, Punjabi University, Patiala
City: Patiala STATE: Punjab
PIN CODE: 147002
EMAIL: ermandeep0@gmail.com
Dr.B.Hemavathi
Designation: Assistant Professor in Zoology (On Contract)
Department:Biosciences and Sericulture
Institute:Sri Padmavati Mahila Viswavidyalayam,Tirupati
District: Tirupati City:Tirupati State: Andhra Pradesh
mailID:hemavathispmvv@gmail.com
Dr. K. V. Shalini
Assistant Professor Department of Biochemistry and Biotechnology
Avinashilingam Institute for Home Science and Higher Education for Women Coimbatore, Tamil Nadu.
shalini_bc@avinuty.ac.in
Dr. Nand Kumar Kashyap
Designation Research Scholar Department of Chemistry
Dr. C. V. Raman University Kota, Bilaspur, Chhattisgarh, India-495113
nandk79@gmail.com

Article History
Received: 06 September 2023
Revised: 05 November 2023
Accepted:08 December 2023

Abstract: Biomedical Signal Processing takes into consideration the steps and the stages included in the preprocessing of physiological signals, recording the data, and examining the trends in the dataset. Such an aspect has been achieved with the aid of digital transformation of the working grounds in the healthcare industry. Through the inclusion of thematic analysis, key themes and concepts are drawn based on the secondary qualitative evidence gathered, and the information was inspected as per the views and opinions of the authors and co-authors.

Keywords: Biomedical Signal Processing, BSP, Healthcare Industry, Healthcare Application, Physiological Signals, Patterns and Trends, Patient Satisfaction

Introduction

Biomedical Signal Processing or BSP has been regarded as a key tool on the digital interface used for the extraction of meaningful evidence for the identification of patterns and recognition of trends within the signals produced by the patients. According to the views of Remeseiro & Bolon-Canedo (2019), various kinds of biomedical signals such as neural activities of the brain, the rhythm of the heart movement of the muscles, and other philosophical activities within the body can be captured with the help of tools and technologies. On the other hand, as per the notions by Roy et al. (2021), imaging of the brain, phonetic and non-phonetic utterances, breathing patterns and oxygenation are also present within the process of BSP. Therefore, an extensive number of trends and attributes in the body can be recognised with the help of the processing of such biosignals, and identification of the condition of the patient can be achieved.

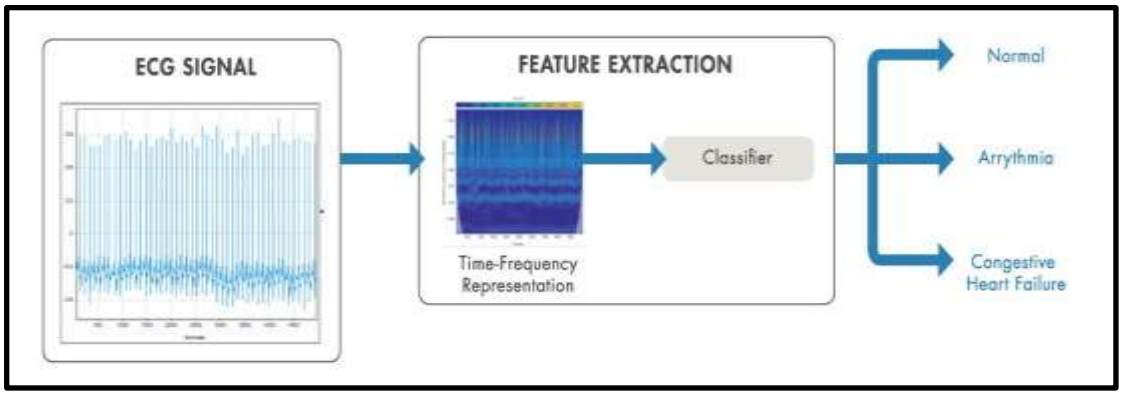

Figure 1: BSP with the help of ECG signal

(Source: Roy et al. 2021)

As noted in the above figure, the ECG signal is recognised with the help of feature extraction as a part of a digital tool and signal processing algorithms can help in the identification of the trends in the signals. For instance, future extraction can be performed both manually or automatically and different signal processing techniques like AR modelling, Fourier analysis, and other tools can be used for the interpretation of the biosignals. Therefore, the tools associated with BSP have been seen to provide an extensive number of services to consumers and have helped in increasing the rate of patient satisfaction.

Aim

The study aims to examine the innovations and issues of Biomedical Signal Processing and the healthcare associations.

Objectives

The objectives developed for the study are mentioned below:

RO1: To examine the factors linked with the rise of BSP in the medical sector

RO2: To inspect the beneficial impact of BSP in terms of data analysis and patient recovery, in the healthcare industry

RO3: To evaluate the issues linked with BSP usage and application in the healthcare sector

R04: To analyse the strategies to be adhered to, by the medical facilities, to increase the potential of BSP application

Literature Review

Critical assessment of the factors of BSP and its usage in the medical industry

According to the findings by Rong et al. (2020), one of the key factors linked with digital disruption and the inclusion of biomedical signal processing within the medical factor is digital innovation and its rise in efficiency. On the other hand, as per the point of view of Hosseini, Hosseini & Ahi (2020), the demand from the ends of consumers which has caused a change in the supply and demand dynamics has also increased the inclusion of digitalisation within the medical sector. Therefore, it can be identified that the key factors that have affected the usage of BSP and altered the efficiency of medical services positively have been increased innovation and dynamic demand chain.

Critical examination of the importance of BSP in raising patient satisfaction

According to the workings by Tobore et al. (2019), early detection of diseases has been enabled with the help of such a process as the machine learning tools used in BSP can analyse the data and help in the reduction of subtle changes within the physical parameters. Such an aspect directly increases the ability of the doctors to detect the diseases from a basal level, even before the extensive rise of their symptoms.

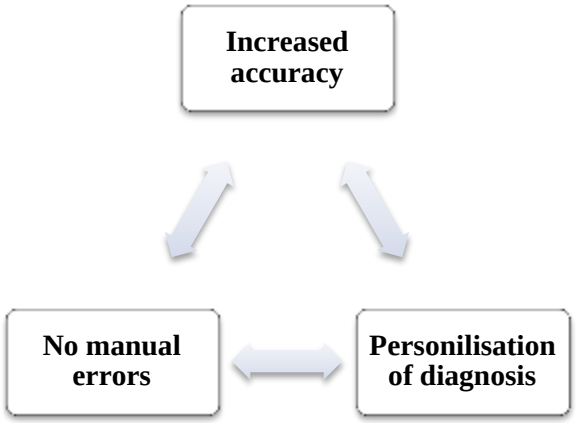

Figure 2: Beneifts of BSP tools

(Source: Influended by Sevakula et al. 2020)

On the other hand, in the thoughts and beliefs by Sevakula et al. (2020), improvement of accuracy and personalised medicine can be provided to the patients based on the progression of the diseases at their own pace. Therefore, the inclusion of BSP has been observed to play a major role in increasing the rates of satisfaction and improvised medicine provision to the patients.

Critical analysis of the shortcomings of applying BSP in the healthcare sector

As per the statements by Wasimuddin et al. (2020), capturing biomedical signals in a high resolution and high quality is majorly restricted due to the absence of improved hardware. On the other hand, as dictated by Subramani & BD (2021), talented workers and skilled labourers who are well aware of the different technical grounds of the technology for handling biomedical signal processing are few. Hence, the extensive application of BSP has not yet been integrated into the industrial-level internship cost and skilled labourers.

Methodology

The steps on the strategies that are followed during the collection of data and inspection of the same to reach a constructive conclusion are termed as research methods.

Segregated into several strategies, the study has included descriptive research design and the positivism research philosophy. As per the opinions of Mohajan (2018), descriptive research design allows an extensive examination of the different variables linked to the topic. On the other hand, as thought by Pandey & Pandey (2021), positivism research philosophy focuses on factual information and helps in the examination of such evidence based on its situation of occurrence. Secondary qualitative data from the search database of Google Scholar and analysed with the help of thematic analysis. Significant themes based on the examination of the research objectives were drawn to accomplish the aim and objectives of the study.

Findings

Digital disruption and innovation for increasing the application of biomedical signal processing in the medical sector

Improvement of healthcare diagnosis and the treatment for the patients have been enabled with the inclusion of BSP as medical decision-making has been enabled. Digital disruption of the medical sector has enabled such procedures to take place and innovation in artificial intelligence and machine learning, Big data analytics and cloud computing have enabled the processing of such data. For instance, as viewed by Subasi (2019), biomedical signals such as electroneurogram, electromyogram, electrocardiogram, and others are integrated into the signal processing software, which is then analysed with the help of machine learning techniques.

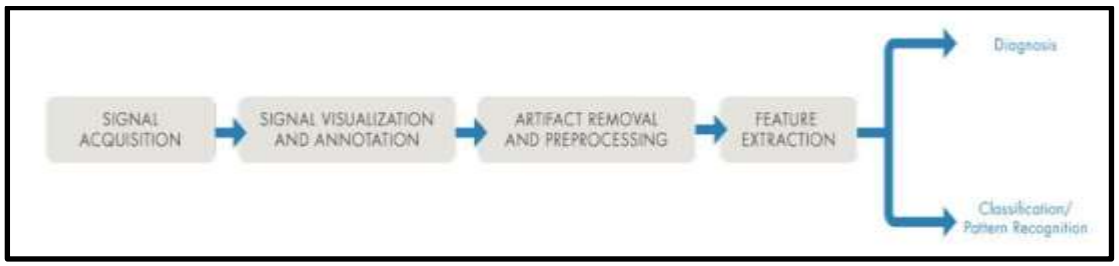

Figure 3: Signal collection and interpretation

(Source: Rahul, Sora & Sharma, 2019)

As illustrated in figure 2, signal acquisition from the physiological signals is processed with the help of signal visualisation, to identify the time, frequency and other such domains. Unwanted artefacts or noises are removed for increasing the efficiency of the signals which are then analysed with the help of signal processing. As per the views of Rahul, Sora & Sharma (2019), the inclusion of innovation and digital disruption has enabled the effective processing of such aspects and has allowed the medical sector to flourish.

Rise of patient satisfaction rate and increase medical performance through biomedical signal processing

An expansion in the procedures to handle medical information and analyse them with high accuracy helps the patients and their families to generate a rate of satisfaction. Manual analysis of such a humongous amount of information would induce manual errors and become cumbersome for the analysts. As stated by Dastidar & Panigrahy (2021), such a negative consequence of manual errors has been decreased drastically due to the automatic processing of the evidence with the help of machine learning tools.

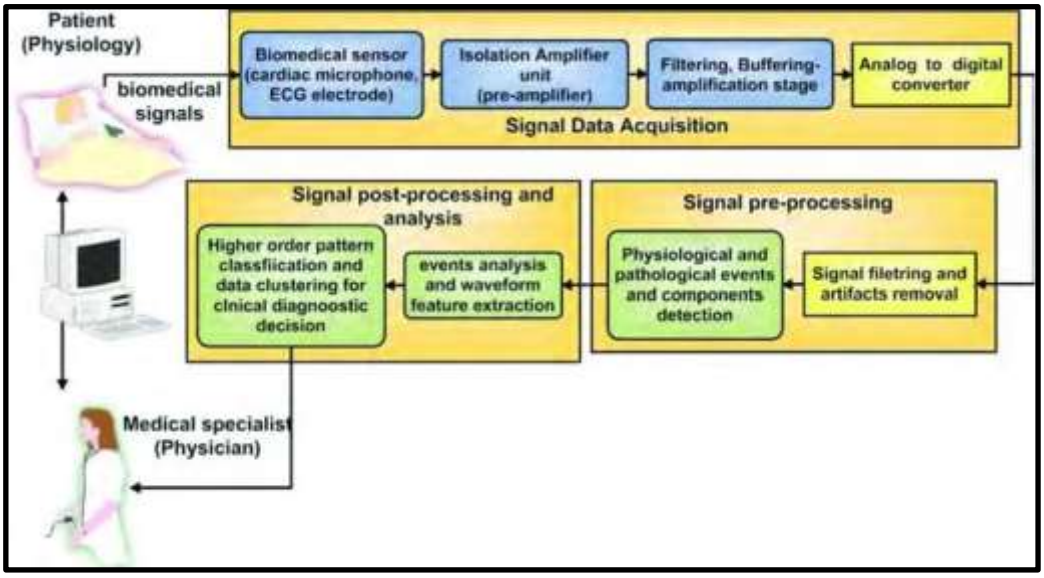

Figure 4: BSP application for patient data analysis

(Source: Katiyar, Kumari & Srivastava, 2022)

The continuous monitoring of the biomedical signals can help the rise of accuracy as large volumes of biomedical data can be inspected within a short period of time. In addition to such, as mentioned by Katiyar, Kumari & Srivastava (2022), improved accuracy allows the doctors to modulate the diagnosis process of the patient for personalising the medical procedures. Such an aspect drastically increases the efficiency of the medical domain and gives a greater performance to meet the needs and demands of the patients.

Shortcomings of financial constraints and ineffective labourers to hamper the biomedical signal processing

Novel technologies such as machine learning and artificial intelligence are extremely costly and cannot be afforded by a significant number of medical facilities due to their restricted revenue flow. As per the thoughts by Subasi (2019), the utilisation of BSP is significantly decreased due to its expensive rates and the inability to obtain the materials at a subsidised cost. The majority of medical facilities do not have such a high budget, which decreases their probability of investing in such expensive technologies. On the other hand, as depicted by Hosseini, Hosseini & Ahi (2020), there is a lack of a significant number of experienced IT workers who are extremely proficient in handling the tools and technologies of BSP. Therefore the main shortcomings and challenges associated with the application of BSP are the financial constraints and lack of technical expertise.

Strategies for improving the application and utilisation of biomedical signal processing in forthcoming endeavours

Training and services are to be provided to the skilled IT professionals for increasing their capacities to handle biomedical signal processing and increase the efficiency of the medical industry. According to the comments by Sasikala et al. (2022), the expansion in the skill set of the experience of its workers will be necessary for using the tools of BSP to their utmost efficiency and providing the customers with heightened care. On the other hand, as per the suggestions by Dastidar & Panigrahy (2021), innovation and creativity ought to be fostered within the medical industry for further increasing newer methods to reduce the cost of BSP tools, and making them available to a larger number of consumers. Therefore, in the

fourth coming domains of the medical sector increased innovation and creativity would play a significant role to decrease the expense of Biomedical Signal Processing technologies, and increase in the quality of medical service.

Discussion

Operation of engineering principles and different types of digital techniques have been administered in the medical industry for the development of BSP. The application of BSP has seen an extensive utilisation in the medical sector because of the range of benefits it provides to the patients and directly increases the rate of patients satisfaction. The occurrence of Industrial Revolution 4.0 has induced an extensive degree of digital destruction within the medical sector. As per the depictions by Domínguez-Jiménez et al. (2020), such an expansion has greatly impacted the extent of innovation and creativity within the medical industry adding to the expansion of BSP. However, as commented by Subramani & BD (2021), the application of BSP has been seen to suffer from several shortcomings on challenges at the industrial level, especially for organisations with constructed finance as the tools are extremely costly. Strict strategies, such as increase in training of the IT professionals and fostering innovation within the medical grounds are to be approached by the health care industry for promoting a greater usage of the BSP tools.

Conclusion

Hence, the study has focused upon the different applications of Biomedical Signal Processing, the associated tools and technologies, alongside the strategies necessary for further increasing the application and utilisation of the same. On the other hand the benefits and the shortcomings of applying such tools in an extensive level have also been identified. Increase patient efficiency and early detection of the diseases for a continuous monitoring of the procedures have been identified to be the major pros of using Biomedical Signal Processing. However, the lack of extensive financial funds due to the expensive digital tools of BSP and the lack of skilled labourers to handle the operations have been noted to be the shortcomings of the technologies. With the help of thematic examination, the concepts related to the innovative and creative grounds and the mitigation of the challenges for using BSP has been analysed in the study.

References

Dastidar, A., & Panigrahy, D. (2021). Preprocessing of the electrocardiogram signal for a patient parameter monitoring system. In *Electronic Devices, Circuits, and Systems for Biomedical Applications* (pp. 115-133). Academic Press. https://www.sciencedirect.com/science/article/pii/B9780323851725000265

Domínguez-Jiménez, J. A., Campo-Landines, K. C., Martínez-Santos, J. C., Delahoz, E. J., & Contreras-Ortiz, S. H. (2020). A machine learning model for emotion recognition from physiological signals. *Biomedical signal processing and control*, *55*, 101646. https://www.sciencedirect.com/science/article/pii/S1746809419302277

Hosseini, M.P., Hosseini, A. & Ahi, K., (2020). A review on machine learning for EEG signal processing in bioengineering. *IEEE reviews in biomedical engineering*, *14*, 204-218. https://ieeexplore.ieee.org/abstract/document/8972542/

Katiyar, K., Kumari, P., & Srivastava, A. (2022). Interpretation of Biosignals and Application in Healthcare. In *Information and Communication Technology (ICT) Frameworks in*

Telehealth (pp. 209-229). Cham: Springer International Publishing. https://www.sciencedirect.com/science/article/pii/B9780323851725000265

Mohajan, H. K. (2018). Qualitative research methodology in social sciences and related subjects. Journal of economic development, environment and people, 7(1), 23-48. http://ojs.spiruharet.ro/index.php/jedep/article/view/571

Pandey, P., & Pandey, M. M. (2021). Research methodology tools and techniques. Bridge Center. http://dspace.vnbrims.org:13000/jspui/bitstream/123456789/4666/1/RESEARCH%20METHODOLOGY%20TOOLS%20AND%20TECHNIQUES.pdf

Rahul, J., Sora, M., & Sharma, L. D. (2019). An overview on biomedical signal analysis. *Int. J. Recent Technol. Eng*, *7*(5), 206-209. https://www.researchgate.net/profile/Jagdeep-Rahul/publication/330779514_An_overview_on_Biomedical_Signal_Analysis/links/5c542086299bf12be3f2a3f1/An-overview-on-Biomedical-Signal-Analysis.pdf

Remeseiro, B., & Bolon-Canedo, V. (2019). A review of feature selection methods in medical applications. *Computers in biology and medicine*, *112*, 103375. https://www.sciencedirect.com/science/article/pii/S0010482519302525

Rong, G., Mendez, A., Assi, E.B., Zhao, B. & Sawan, M., (2020). Artificial intelligence in healthcare: review and prediction case studies. *Engineering*, *6*(3), 291-301. https://www.sciencedirect.com/science/article/pii/S2095809919301535

Roy, V., Shukla, P.K., Gupta, A.K., Goel, V., Shukla, P.K. & Shukla, S., (2021). Taxonomy on EEG artifacts removal methods, issues, and healthcare applications. *Journal of Organizational and End User Computing (JOEUC)*, *33*(1), 19-46. https://www.sciencedirect.com/science/article/pii/S0010482519302525

Sasikala, K., Sharanya, C., Jothilakshmi, G. R., Vijayalakshmi, A., Sahaai, M. B., & Ganesh, E. N. (2022, May). Design and implementation of bio signal platform using Internet of Things. In *AIP Conference Proceedings* (Vol. 2463, No. 1). AIP Publishing. https://pubs.aip.org/aip/acp/article-abstract/2463/1/020017/2825276

Sevakula, R. K., Au- Yeung, W. T. M., Singh, J. P., Heist, E. K., Isselbacher, E. M., & Armoundas, A. A. (2020). State- of- the- art machine learning techniques aiming to improve patient outcomes pertaining to the cardiovascular system. *Journal of the American Heart Association*, *9*(4), e013924. https://www.ahajournals.org/doi/abs/10.1161/JAHA.119.013924

Subasi, A. (2019). *Practical guide for biomedical signals analysis using machine learning techniques: A MATLAB based approach*. Academic Press. https://books.google.com/books?hl=en&lr=&id=80yNDwAAQBAJ&oi=fnd&pg=PP1&dq=+biomedical+signals+such+as+electroneurogram,+electromyogram,+electrocardiogram&ots=Ej8ZkFOc-x&sig=4ORGznwURtAY7x5tZVezoodsexY

Subasi, A., (2019). Biomedical signal analysis and its usage in healthcare. *Biomedical Engineering and its Applications in Healthcare*, 423-452. https://link.springer.com/chapter/10.1007/978-981-13-3705-5_18

Subramani, P., K, S., & BD, P. (2021). Prediction of muscular paralysis disease based on hybrid feature extraction with machine learning technique for COVID-19 and post-COVID-19 patients. *Personal and ubiquitous computing*, 1-14. https://link.springer.com/article/10.1007/s00779-021-01531-6

Tobore, I., Li, J., Yuhang, L., Al-Handarish, Y., Kandwal, A., Nie, Z. & Wang, L., (2019). Deep learning intervention for health care challenges: some biomedical domain considerations. *JMIR mHealth and uHealth*, *7*(8), 11966. https://mhealth.jmir.org/2019/8/e11966/;

Wasimuddin, M., Elleithy, K., Abuzneid, A. S., Faezipour, M., & Abuzaghleh, O. (2020). Stages-based ECG signal analysis from traditional signal processing to machine learning approaches: A survey. *IEEE Access*, *8*, 177782-177803. https://ieeexplore.ieee.org/abstract/document/9206538/