ISSN : 2582-7405

Transaction on Biomedical Engineering Applications and Healthcare

Volume No. 6

Issue No. 3

SEP- DEC 2025

ENRICHED PUBLICATIONS PVT. LTD

JE-18, Gupta Colony, Khirki, Extn, Malviya Nagar, New Delhi-110017
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ISSN : 2582-7405

Transaction on Biomedical Engineering Applications and Healthcare

Aims and Scope

The primary objective of the **Transaction on Biomedical Engineering Applications And Healthcare journal,** popularly known as the TBEAH journal, is to serve as a comprehensive, open-access platform that is dedicated solely to facilitating the progress and advancement of the field of Biomedical Engineering by -

offering gifted and talented researchers engaged within the domain of Biomedical Engineering a unique setting for them to get their work published and elevate their reputations/standing within the global community, as well as,

providing professionals, students, academics, and scholars free access to the latest and most advanced research outcomes, findings, and studies, being carried out in the field of Biomedical Engineering, all across the world.

Subject Area

RELATED TOPICS:

1. Biomedical signal processing
2. Biomedical imaging and image processing
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9. Neural and Rehabilitation Engineering
10. Biomechanics
11. Robotics
12. Therapeutic and diagnostic systems, devices and technologies
13. Clinical Engineering
14. Healthcare information systems and telemedicine
15. Other emerging topics in biomedical engineering

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(Volume No. 6, Issue No. 3, SEP - DEC 2025)

Contents

ISSN : 2582-7405

Amalgamation of Industry 4.0 and Healthcare within Biomedical Engineering

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ABSTRACT

The research article is important because the article has chosen a unique field of engineering that is biomedical engineering and has subsequently tried to establish a relationship between Industry 4.0 that includes different types of new and innovative technologies along with the healthcare industry. The findings have showcased that IoT has been the most used technology in every industry including the healthcare industry. The result where a pandemic such as TB has been cured because of the implementation of machine learning algorithm used with biomarkers to fetch out a novel treatment for the masses indicates the capability of AI technology in both healthcare and biomedical engineering.

Index Terms -AI Technology, Bioengineering, Biomedical Engineering, Healthcare, Industry 4.0

I. INTRODUCTION

The article is significant as Industry 4.0 is about integrating different types of new technologies such Internet of Things (IoT), Artificial Intelligence (AI technology), cloud computing, and others. The healthcare industry is one of the growing industries that has implemented industry 4.0 to curb down the time, cost and also for better solutions. It has been seen that early detections and medical treatment of different diseases is possible through Industry 4.0 in the healthcare industry. Industry 4.0 is considered to be an innovative approach that has helped in manufacturing enhanced quality of medical devices that has been customised as per the patient's requirements [1]. It somehow offered a digital hospital to the patients as well as a monitoring system to fulfill the requirements of the patients in the healthcare industry at optimal cost and also time. The connection with data and data exchange has been established with the help of Industry 4.0.

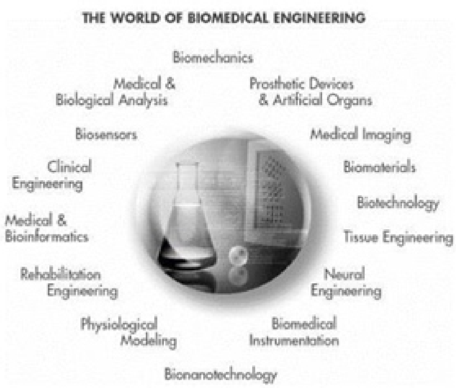

Figure 1: Biomedical Engineering[2]

The relationship between industry 4.0 and healthcare has been formed and understood through the implementation Industry 4.0 in the specific industry. The aim of the study is to establish a relationship between Industry 4.0, healthcare and also biomedical engineering. Biomedical engineering is considered to be an application of the principles of engineering to resolve the issues associated with health and healthcare. Biomedical engineering requires the application of knowledge, approaches along with concepts of every engineering discipline such as chemical, electrical and others. It can be better understood through the designing of medical imaging modality and creation of devices of medical prosthetics to help out people possessing disabilities [2]. The development of imaging modality and medical prosthetics have been taking place with the assistance of biomedical engineering to help the patients in the healthcare industry. There are different pursuits within the field of biomedical engineering such as creation of diagnostic instruments with the help of blood analysis, creation of diagnostic imaging systems, designing of different biomedical sensors, development of dental materials and others [2]. The other pursuits include development and creation of materials for replacing the human skin, development of telemetry systems as per monitoring the patients. AI-technology has been witnessed to be implemented in the biomedical sector and utilisation of AI has common for determining the data types in the biomedical sector. Multi-omics data encompasses proteomics, epigenomics, microbionics, proteomics and others. This type of data has been collected and also analysed. There has been an integration of data that has been taken from mRNA and also from "single-nucleotide polypmorphisms" to develop a model namely, Bayesian integrative model [3]. Therefore, it is clear that the biomedical sector has already implemented AI-based technology to analyse different types of data. There is no synergy witnessed where it has been seen that automation (as part of Industry 4.0), biomedical engineering along with "health informatics technologies" does not respond to each other. The above problem of absence of synergy can be better understood through an example on Smart Home that has been demonstrated by Bill Gates. He has depicted the point devices, along with the systems that have been created for monitoring the human activities, tracking of the health status, checking the operations of different home appliances yet these systems possess open loop and subsequently isolated from each other [4]. This is an issue that has been identified between using automation, biomedical engineering and also informatics technologies in the healthcare industry. There are issues with Industry 4.0 as well where it has been found that data integration has become one of biggest hindrances. Data integration is about the combination of various types of data in a single or unified view. The data that has been collected are not enough after collecting it for the single view and are not accurate to provide effective solutions to the patients.

REVIEW OF LITERATURE

Bioengineering and Biomedical engineering

Biomedical engineering involves the application of the various principles within engineering to solve out the problems in the healthcare industry. [6] argued that biomedical engineering improves the quality of life through improving advanced technologies as well as materials. The various medical equipment along with medical processes have been developed with the help of knowledge within healthcare, engineering and also viology. It has been further seen that those designs of the medical equipment along with processes have further helped in improving the health outcomes. The difference between bioengineering and biomedical engineering is that the various practices of engineering have been applied to different biological systems including healthcare, agriculture and also pharmaceuticals. However, medical engineering is a subset of bioengineering focusing on applying those engineering practices on the healthcare industry only rather than on other industries such as pharmaceuticals and agriculture. The various types of medical devices are basically designed through biomedical engineering.

Application scenarios for implementation of Industry 4.0 in healthcare

IoT has been leveraged for monitoring every facet helping in healthcare implementation within the settings of elder care, home surveillance and also on the rehabilitation system of the healthcare. [7] opined that these setups (of IoT and healthcare implementation) help in producing huge volume and different types of data through enabling big-data technologies. There is another shift that has been witnessed through the usage of cloud infrastructures which is an essential part of Industry 4.0. The cloud infrastructure helps in secure handling of large data. IoT revolves around establishing a connection at anytime and anywhere through focusing on digital identification along with machine-to-machine learning. The objects that have been utilised in the IoT encompasses certain understandings and also connotations associated with Radio-frequency identification (RFID) and "Wireless Sensor Networks" (WSNs) to further understand power consumption, capabilities and others.

IoT Paradigm		Year	Ref.
Internet of Medical Things	(IoMT)	2017	[45]
Internet of Health Things	(IoHT)	2016	[41]
Internet of Nano Things	(IoNT)	2015	[2]
Wearable Internet of Things	(WIoT)	2014	[44]
Internet of m-health Things	(m-IoT)	2011	[46]

Figure 2: Different paradigms of IoT in the healthcare industry[8]

"Wireless Body Area Networks" (WBANs) is used as part of IoT in healthcare and is composed of various wireless devices that includes both sensors and actuators that have been either attached or rather implanted within the human body. [8] argued that IoT is associated with different layers **where** the perception layer consists of sensors and actuators while transmission layers convey certain sensed information with the upper layer. Computation layers are in charge in terms of processing data while the last layer, that is the application layer, is provided with the charges of utilising IoT infrastructures to attain the goals in healthcare and others. The information flows through these layers in the IoT providing an opportunity to track health status.

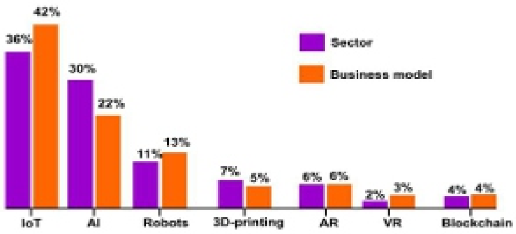

Figure 3: Increasing use of IoT among all the new technologies[9]

Wearable Internet of Things (WIoT) provides automated intervention through telehealth while Internet of Medical Things (IoMT) offers wearable devices. [9] stated that IoT has been efficient for monitoring, service delivery at remote places, real time data of the market and others. "Cloud and Fog Computing" assists in carrying out the operations in a simple way and it does not require resources that allow "pay-per-use billing" (allowing customers to make a purchase on a single amount). Thus, the patients and families in the industry make use of this technology to pay a specific amount within a short time. There is a shortcoming in cloud computing where communication between end device and datacentre is possible rather than involving several users while fog computing is more helpful in healthcare where the technology has improved service delivery in the However, information sharing within medical structures is possible through "Cloud-based Health Information Systems" where both hospitals and patients have benefited with the objective of integrating data in several formats.

Utilisation and identification of new technologies and healthcare areas through Biomedical engineering

Biomedical engineering makes use of engineering practices in the healthcare industry where it is important to understand what type of technology is used while developing and designing imaging modality or prosthetic devices. [10] stated that imaging modalities are categorised through several methods based on generating images which includes ultrasound and radiation that includes X-rays and also "Magnetic Resonance Imaging" (MRI) (an imaging technology producing anatomical images). The designing of imaging modalities has been carried out in a way that it contains the appropriate energy sources which includes light, X-rays, ultrasound, electrons and others. However, after designing it using concepts and knowledge of chemical, electrical and mechanical engineering where every energy source has a connection with a specific type of engineering. The healthcare industry requires these imaging modalities to visualise the body of a human being for the treatment and also diagnostic

AI technology of Industry 4.0 has certain algorithms in the form of deep learning that have helped in the interpretation of different complex data. [10] argued that AI helps in recognising various complex patterns within the imaging data that further offers quantitative assessments rather than qualitative assessments within the radiographic characteristics. AI methods have been seen to be relying on engineering algorithms where these algorithms have been designed for quantifying radiographic characteristics which includes “3D shape of a tumour” or “intratumoural texture and distribution of pixel intensities”. The relationship can be better understood through the fact that biomedical engineering develops medical equipment for the healthcare industry while AI technology identifies the complex pattern within that equipment for diagnosing and medical treatment in the healthcare

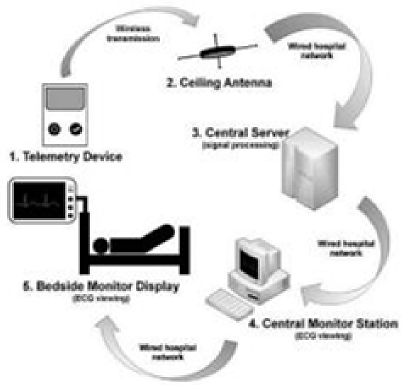

Figure 4: ECG for Telemetry System [11]

Biomedical engineering has a direct association with requirements of the medical devices as well as equipment in the healthcare industry whereas difficult patterns of a disease and diagnosis within that equipment is understood through diverse technologies in Industry 4.0. According to the words of [11], modulation systems have been utilised for transmitting various biomedical signals possessing two modulators such as “Frequency Modulator” (FM) along with “Pulse Width Modulator” (PWM) in a wireless telemetry. Thus, it involves the measurement of different biological parameters within a specific distance while transmitting that data from the generation point to the reception point. There are some psychological parameters that seem to be adaptable within the biotelemetry that includes bioelectrical variables involving ECG, “electroencephalogram” (EEG) and others. The psychological variables are in dire need of transducers that include blood pressure, blood flow, temperatures and others.

The accuracy within a telemetry can be obtained through the preparation of electrode placement, lead, skin, equipment maintenance and also on patient monitoring. The preparation process involves the function of biomedical engineering in the wake of designing it. [12] argued that telemetry systems are also designed with the help of biomedical engineering and are used for monitoring the patients in the healthcare organisations. Telemetry or biotelemetry is an important process that involves recording and also transmitting instrument readings associated with human functions, activities along with condition.

Electrocardiogram (ECG) is a tool that helps in the diagnosis of cardiac diseases however, telemetry on the other hand helps in monitoring ECG of the patient. However, an IoT-based telemetry is found to be more productive for offering both indoor and outdoor data of the patients to monitor the indoor and outdoor environment.

MATERIALS AND METHODS

Secondary sources such as journal articles have been found to be beneficial for studying the application of biomedical engineering through merging new technologies and the selected sector to identify the methods [13]. AI systems are found within biomedical engineering where the AI system has the capability to track molecules in the living cells. The AI system is prepared through a neural network where the technology has been trained to put a single focus on the sample and possess the capability to track fluorescent molecules in the cells. The tracking of different types of molecules makes way for the molecule interactions and at various concentrations that is associated with a fundamental side of cell biology. There are several researchers from Osaka University and also from RIKEN who have delved into the development of an AI system [14]. In a laboratory, an AI system has been seen to be applied in the imaging as well as analysis within "epidermal growth factor receptors" (EGFRs) in different cells on the plates that have been kept for a particular day. It has been further witnessed that AI systems have the capability to make a distinction between the modified as well as unmodified EGFRs. The experiment has been essential as this experiment has highlighted the potential of the AI technology to identify both the modified and unmodified ones. The neural networks within the AI technology have been found to be helpful for identifying the EGFRs. In this regard, the relation between biomedical engineering and a new innovative technology such as AI has been established through the experiment.
In another experiment, it has been derived that utilisation of "high-resolution liquid spectrometry (LC-MS)" for testing out the around 191 of the blood samples followed by the discovery of "kynurenine" (Kyn), "Indoleamine 2, 3- dioxygenase" (IDO) and also of the "tryptophan" (Trp) which have offered an excellent result. The experiment revolved around using LC-MS and those discoveries in the form of some effective biomarkers [14]. Application of logistic regression algorithm have fetched the results where the algorithm has helped identifying the pulmonary TB for further classification of "health control (HC) vs active tuberculosis (ATB)" and "latent tuberculosis infection (LTBI) vs ATB"

RESULTS AND DISCUSSION

Result

The findings will be collected through understanding the application of biomedical engineering in the designing process of medical devices. Assistive technologies that include orthotic and prosthetic devices that have always existed for several centuries. There has been an increase in use of "additive manufacturing technologies" (AMT), namely "3D printing technologies" where 3D printing is considered to be an important part of Industry 4.0. The technologies in 3D printing have emerged with the introduction of a "stereolithography technique". It has been further found that AMTs have been an essential part of rapid prototyping techniques (RPT) that helps in production and preparation of the functional parts of the human body through a three-dimensional model. The techniques have been beneficial and have been applied while manufacturing exoskeleton parts, passive orthoses and others. The development of RPT has evolved to a great extent in biomedical engineering to meet the requirements of the people in need of certain individualised devices [14]. The adaptability rate in biomedical engineering is more to quickly gain an idea on the anatomical shapes of the patients.

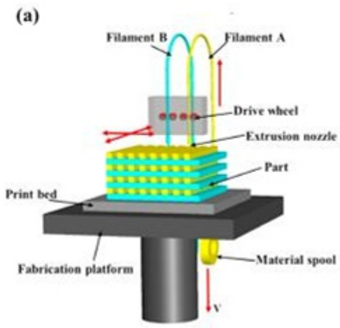

Figure 5: FDM [14]

"Fused Deposition Modeling" (FDM) is considered to be a semi-molten material that has been extruded by an extrusion head that eventually transverses X and Y axis for the creation of the "two-dimensional layer" of that piece that has been manufactured. As FDM technology makes use of materials of low expenses therefore, biomedical engineering has increased the utilisation of FDM for preparing, hand prostheses, upper and also lower limb orthoses, facial prosthesis and others. It is important to note that 3D printing is used along with the use of RPT and FDM within the field of biomedical engineering for designing prosthetic devices [14]. The merging of "computer-aided design" (CAD) and also "computed aided manufacturing" (CAM) have also gained a high momentum within the orthoprosthetic industry. The application of biomedical engineering can be better understood through innovative diagnostic tests that have been made for patients in healthcare for the purpose of curing a deadly disease in earlier times. The tuberculosis (TB) pandemic has been important to understand the role of AI within biomedical engineering where a study has recognised "transcriptomic biomarkers" on the disease. The techniques on machine learning (ML) have further identified metabolite signatures that have a connection with TB progression. There have been some authors possessing training on the use of "random forest machine learning algorithm" as part of the AI technology to further recognise metabolite signatures that have the capability to foretell the TB progress [15]. This specific experiment where the algorithms of machine learning have the capability to point out the biomarkers within the TB progression has been an effective result indicating a novel treatment for this deadly disease through the There are some other studies that have further mentioned about certain other algorithms that are capable enough for identifying some biomarkers in connection to some pathological conditions. However, there is an exceptional area where biomarkers cannot be utilised in fixing and also treating of the tumor tissue because those biomarkers do not possess the accuracy that is needed for the purpose of patient stratification along with medical treatment. Conversely, microfluidic systems are effective in case it is utilised with cell biomarkers and the algorithms of machine learning that may offer better outcomes and enhanced stratification for the patients. The result has a tone of 'Turing Test' where a computer's intelligent behaviour may prove to be effective for obtaining human-level performance within certain cognitive-related tasks [15]. Thus, it is evident that either biomarkers with algorithms in machine learning or combination of algorithms with microfludic systems and cell biomarkers may produce effective results. AI has been designed in a way that the programs have the capability to resolve problems as per human thinking skills.

Discussion

Figure 6: 3D Orthotics [15]

Biomedical engineering applies every concept and knowledge of engineering virtually. In this regard, the biomedical engineers have engaged themselves in the creation of the biosensors that will eventually interact with prosthetic devices to detect and make use of bioelectric signals for powering the prosthetic device [15]. The processes on traditional manufacturing have been mostly found to be hand-crafted and also need special abilities on the side of the orthopaedist to prepare a quality product. The morphology acquisition is considered to be not a clean process with the utilisation of the plaster to make the mould. However, the manufacturing process has always created a discomfort among the patients while it has been found that the final product has produced a blistering effect on the skin of the patients. RPT and AMT possess an immense potential to improve the designing process of the orthotic and prosthetic products even also the manufacturing process associated with it. The utilisation of RPT within the orthoprosthetic industry has been considered to be a productive change that has eventually offered important benefits. Therefore, the function of biomedical engineering is not possible alone until a technology is considered.

The main aim is to enhance the overall reconstruction process through "3D analtomical models along with the biomedical products. In this aspect, it can be further stated that production of devices within biomedical engineering strengthens with the potential of RPT and AMT. The CAD followed by the facilitation of the design through RPT and custom-fit prosthetic and orthotic products have been prepared within biomedical engineering with the utilisation of materials, virtual testing and others [15]. TB is a public health issue according to the World Health (WHO) as the disease has been spreading within half of the population within the world. There are some diagnostic techniques which include TB culture test, "Sputum acid-fast bacillus" and others that have certain limitations. The disadvantage of the TB test is that it takes much time to produce effective results and the time limit is found to be around 4 weeks. In such a grave scenario, there is a dire requirement for some cost-effective diagnostic tests [15]. One of the important applications of biomedical engineering revolves around offering invention through the assistance innovative diagnostic tests for various diseases. It is true that LC-MS has produced the desired results and has been successful for the classification of the various types of TB. However, the recognition of the biomarker is more helpful within the blood to identify the normal and abnormal sign of the disease as found while treating the people during the TB

The healthcare industry is one of the fastest growing industries and it has implemented industry 4.0 to reduce the cost and time and obviously get better solutions. From the above study, it has been seen that previous and traditional methods of detection and process of medical treatment can detect the different diseases with proper and manual medical tests. In modern days, Industry 4.0 has an excellent positive impact on detecting and controlling the disease as well [16]. From this research study, It has been seen that the designs of modern and advanced medical equipment helped to improve health outcomes with accuracy. There are many differences between bioengineering and biomedical engineering that promotes various practices of engineering segment and it also has been applied to different kinds of biological systems including healthcare, agriculture, as well as pharmaceuticals This study has applied "additive manufacturing technologies" (AMT), and "3D printing technologies to get the better outcomes from the research study and it has been seen that Biomedical engineering increased the utilization of FDM to prepare facial prosthesis, hand prostheses, limb orthoses, and many more [17]. On the other hand, the development of RPT has involved biomedical engineering to meet the essential requirements of individuals. accordingly, the rates of adaptability in the biomedical engineering process are more to gain the efficient quickly and idea on the anatomical shapes and biological structure of the patients.

CONCLUSION

This study is based on Industry 4.0 and healthcare with the biomedical engineering process. From this study, it has been seen that previous process detections and the process of medical treatment of different diseases are possible through Industry 4.0 in the healthcare industry. The connection between healthcare and industry 4.0 has originated by the process of understanding and industry 4.0 implementation in a particular industry. Healthcare industry has been benefitting from the new technologies.This study has also discussed the AI technology that helps to promote the biomedical sector in a modern way. This study also focused on the stem cell therapies that are capable of transforming medicine by enabling the regeneration of disease and immature tissues. On the other hand, it also injures the tissues and assists in curing certain intractable diseases of humans such as diabetes, muscular dystrophy, neurodegeneration" and many more. This study also highlights the application process of implementing industry 4.0 in the healthcare system. In this study, it has been seen that infrastructure allows for the secure handling process of data. Accordingly, IoT revolves around establishing communication at anytime and anywhere by focusing on digital identification systems with updated machine-to-machine learning methods. The utilized objects in the IoT encompass certain understandings and also try to have connotations that are associated with Radio-frequency identification (RFID) and "Wireless Sensor Networks" (WSNs) to better understand power consumption, strength, and capabilities.

RECOMMENDATION

- Medical sector needs to implement industry 4.0 which helps to improve the patterns of treatment efficiently
- Medical industry should use new technologies that assist individuals to gets better facilities and care for the welfare of the patients

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ISSN : 2582-7405

Analysis of Innovative Drug Therapies via Nanotechnologies against HIV/AIDS: A Clinical Systematic Review

Basilio Joseaugusto Jose1, Dipak Maity2

ABSTRACT

HIV/AIDS has become one of the key medical concerns as the infection due to the retroviridae family is not completely curable till now. However, the treatment band effectiveness of drug therapy has improved due to the research and investigation on nanoparticle technology. It has been identified that effective antiretroviral (ARV) delivery is possible with the help of a "nanodimensional carrier system". The article has shed light on the ART and nanoparticle delivery system. Besides this, the utilisation of nanotechnology in antiviral drug and drug therapy has been assessed in this study to identify the future scope of nanotechnology in HIV drug therapy and treatments.

Index Terms - AIDS, ART, ARV, CYP Substance, Drug Therapy, HIV, Nanoparticles, Nanotechnology, PLGA

I. INTRODUCTION

The article will point out the importance of nanotechnology-based drug therapies used for "Human immunodeficiency virus infection and acquired immune deficiency syndrome" (HIV/AIDS) that belongs to the Retroviridae family. The nanotechnology-based interventions have been understood through nanocarriers as the delivery of antiretroviral drugs has shown different types of advantages, which includes reduction of side effects and also undesirable interaction of drugs, sustained drug release, and others [1]. Antiretroviral delivery is possible through "nanodimensional carrier systems". Free HIV possesses a propensity of undergoing frequent mutations. This type of mutation has the potential to cause altercation within nature and also confirmation within "Envelope Glycoprotein" (gp120) (found upon the surface of the envelope of HIV). Thus, it is easy to target infected cells rather than free HIV. The important nanotechnology-based systems are explored through different HIV therapeutics which include nanoparticles, polymeric micelles, liposomes and others that will be discussed throughout the article. The main aim of the article is to understand and evaluate those innovative nanotechnologies-based drug therapies for HIV/AIDS in a qualitative way.

Nanotechnology combines both science and technology for designing and producing systems and devices through manipulation of atoms and molecules considered in terms of a nanoscale [2]. Therapeutic interventions provided through nanotechnology have emerged in the form of multidisciplinary fields where nanocarriers tend to shield the drugs from certain delirious interactions with non-target cells and also biological systems. AIDS has been caused by HIV and is considered to be a global pandemic that has eventually affected morbidity and mortality rates in developing and developed countries [3]. In this respect, "Antiretroviral" (ARV) therapy has somehow enhanced the lifespan of people; however, this therapy has increased the mortality rates in some of the developing countries hence its effect is assumed to be worse. The ARV is primarily recommended to every patient except in some cases where the cell count of "CD4 T lymphocyte" (CD4) is looked into. The adverse effects of ART are certain diseases such as diabetes, “atherosclerotic cardiovascular disease”, bone loss, weight gain and others [3]. HIV medicines have been causing side effects among people where it has been witnessed that some of the side effects have been manageable; however, there are a few grave side-effects.

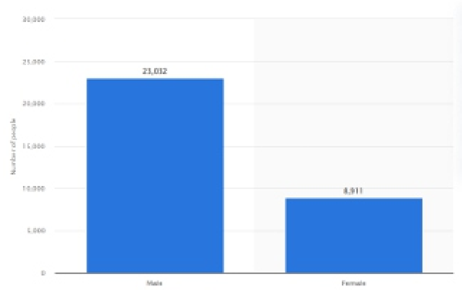

Figure 1: Annual deaths through AIDS among males and females in India in 2020 [4]

Some manageable side-effects from HIV are trouble sleeping, fatigue and others while severe side-effects are high cholesterol that further increases the risk of heart attacks among people suffering from AIDS. HIV eradication is assumed to be an impossible task due to its viral latency in the form of reservoirs and virus sequestration within some privileged organs such as liver, kidney, brain, lymphoid tissue, and others. The above graph is evidence to show that around 23 thousand males have died of AIDS while around 89 thousand females have died of the same disease. 74% of the males have been estimated to have died out of this disease therefore, the death rate from the disease has increased among males as compared with females in a developing country such as India in 2020 [4]. Therefore, it has been proven that mortality rates in developing countries, maybe due to ART therapy, have been worse, unlike the condition in developed countries.

METHODOLOGY

The article has derived relevant information from secondary sources such as journal articles, websites others where only qualitative information has been collected over quantitative information. It can be better specified that only non-numeric information from available journal articles has been used where information related to clinical studies has been incorporated within the discussion. In this regard, nanotechnology has helped in formulating various systems of drug therapy that include nanosuspensions, nano micelles and also nanoemulsions that have proved to improve the therapeutic impacts of several medications. Nanosuspensions of around 200 nm within medication rilpivirine

(TMC278) have been stabilised through “polyethylene-polypropylene glycol” (poloxamer 338) along with “PEGylated tocopheryl succinate ester" (TPGS 1000) that have been examined on dogs and mice based on polymeric systems [5]. In comparison with a half-life of over 38 hours in terms of free medication, a specific dosage of administered drugs in respect of nanosuspensions subsequently causes sustained release in 3 months within dogs and also in 3 weeks within mice [5]. This experiment has somehow proved that the delivery through nanoscale medication possesses the potential to curb down the dosage frequency along with boost adherence. Therefore, the other information from different secondary sources will be discussed below to understand the development of nanotechnology-based drug therapies for treating AIDS. Nanosuspensions are assumed to be a dispersion of colloidal drug particles that are biphaspic and have been stabilised with the help of surfactants. Some recent studies have offered an observation on the above experiment

RESULTS AND DISCUSSION

Result

Systematic review has been carried out to reflect the findings from clinical studies as follows:

Citation	Title of the Article	Findings	Relevance
[6]	“*Biological Aspects and Clinical Applications of Nanoparticles on*	As CD4+ T cells are found to be critical for HIV that has stimulated nanoparticle-based strategies in the form of remedial factors such as “***antiviral***	Nanotechnology has been used in the field of medicine for nanoparticle application

where it has been stated it is possible to stabilise "drug indinavir's nanosuspension" through a surfactant system prepared from Lipoid E80 in respect of equal distribution in the tissues [5]. An absorption rate of indinavir nanosuspensions has been determined after it has injected within the macrophages. The mice have been intravenously injected through macrophage that is seen to be loaded with indinavir nanosuspensions that have been causing a distribution in spleen, liver and other organs. The intravenous delivery from a specific dosage of “nanoparticle-loaded macrophages" produced drug levels within the blood for around 14 days in the aftermath of treatment within "rodent mouse model” consisting of brain infection from HIV. The drug therapy has subsequently led to antiviral activity within the brain [5]. It has been further assumed that “vivo nanoparticle-targeted medication delivery" towards the brain may possess certain benefits where macrophages seem to be applied to target the area of pharmaceuticals within the brain. "Antiretroviral drug delivery" has been utilised in the form of targeting techniques where there are different types of receptors such as “formyl peptide”, “galactose”, “Fc receptors”, “mannose” and others have been witnessed to present over the macrophage’s surface. These receptors have been utilised as “receptor-mediated internalisation" where "medication stavudine" have encapsulated through different liposomes that have been coupled through mannose and also through galactose that reaches the liver, spleen and other organs [. The targeted liposomes have been assumed to offer cellular absorption as well as prolonged-release within the tissues that indicate an improvement to a certain extent for the free medication.

The experiment has been successful where it has been seen that liposomes have been effective in providing drug therapy as part of the innovative approaches through nanotechnology [5]. Zidovudin is an essential medication that has been provided within 1 hour and half-life and possesses limitation in terms of solubility has been derived from "mannose-targeted liposome". However, most of the nucleoside medications including "zidovudine" and also "stavudine" have offered serum half-lives that have been assumed to be of therapeutic significance. It has been further estimated that the future will encourage more on the nanotechnology systems that will further focus on enhancing the half-lives to attain certain lessen the have been assumed to be of therapeutic significance. It has been further estimated that the future will encourage more on the nanotechnology systems that will further focus on enhancing the half-lives to attain certain lessen the frequent dosing.

	Treatment and Prophylaxis of HIV'	***siRNA" and "antiretroviral drugs***" CD4+ T cells for the prevention of HIV replication. There are "***lipid nanoparticles***" aimed at targeting "CD4+T cells" utilising peptides for identifying CD4 co-receptor. The pretreatment through CD4+ T cells while targeting lipid nanoparticles has lessened the number within infected cells in comparison with non-targeted nanoparticles. Conversely, Liposomes (nanomaterial) have been considered to be drug carriers whereas various liposomes have been formulated through "***cardiolipin***" and "***synthetic phospholipids***" through a procedure of ethanol injection. "***Liposomal AAR029b***" has the benefit of increasing medicinal exposure, and enhancing serum half-life that expands "***proteolytic peptide triazoles***" as per the treatment capability of HIV-1 is concerned.	for preventive and therapeutic purposes. Nanotechnology-based systems possess an influence on the systems of drug therapy and also possess the potential to ameliorate the characteristics of the drug. This drug therapy through nanotechnology systems has the power to decrease drug toxicity.
[7]	*"Nanosystems applied to HIV infection: prevention and treatments"*	Delivery agents of "***HIV antigenic peptides***" have been assumed to be cationic Nanocompounds that includes "***G4-70/30 dendrimer***" along with "***β-cyclodextrin derivative AMC6***" for introducing HIV-1 peptides within the "***human dendritic cells***" (DCs). The "***immune-active nanovaccine delivery system***" has the potential to target those DCs that has been further designed through utilising inulin acetate that is assumed to be "***immune-active polymeric material***" (InAc-NPs) that aims to target the TLR4 signaling within the DCs for activation and maturation.	InAc-NPs have shown effective results in the form of producing humoral responses for curing infectious diseases including HIV. Therefore, a nanotechnology approach has offered innovative drug therapy to prevent HIV. However, this drug therapy has been considered to be safe as it does not cause skin toxicity.
[8]	*"Applications of Nanotechnology In Diagnosis and Treatment of Disorders: A Review"*	One of the advancements in nanotechnology has been revolving around "***gold nanoparticles***" (AuNPs) possessing a diameter between 1-100 nm. "Gold nanoparticles" have been considered to be "***biobarcode enhancement examination***" (BCA) which eventually helps in detecting "***HIV-1 p24 antigen***" at its decreased level for offering fast results for HIV/AIDS treatment.	The gold nanoparticles have led to the discovery of "***broad spectrum antiviral drugs***". These antiviral drugs possess the potential for curing different viruses which have been considered to be untreatable.
[9]	*"Novel Approaches in Nanoparticulate Drug Delivery System to Overcome Human Immunodeficiency Virus"*	Various nanoparticulate technologies and methodologies including liposomes, micelles, dendrimers and others have raised interest in AIDS treatment. The drugs that have been encapsulated with liposomes have achieved therapeutic levels in respect of a longer duration. This drug can be balanced through polyethylene glycol (PEG) gatherings associated with "synthetic phospholipids". Dendrimers possess polydispersity while nanometer sizes of those dendrimers provide easier pathway within the biological membranes. Drug therapy through dendrimers delivers the drugs by enclosing	Antiretroviral medicine has been utilised for managing HIV/AIDS where nanotechnology tends to enhance pharmacokinetic properties within those Antiretroviral drugs.

		pharmaceutical ingredient inside of dendrimers.	
[10]	"*Nanomaterials designed for antiviral drug delivery transport across biological barriers*"	Nanotechnology has been utilised in the area of HIV/AIDS development where different ***nanomaterials*** and ***nano architectures*** have been used in the form of HIV vaccine carriers in the wake of proven capabilities to enhance permeability, solubility, and also pharmacokinetics of different earlier HIV vaccines. However, ***nanocarriers have been used in antiviral drugs*** for eradicating HIV reservoirs that have helped in the development of therapeutics as drug therapy to enhance drug effectiveness and curb toxicity.	Namomaterials have been designed of various shapes as well as morphologies that can be used within antiviral therapy where nanometric size permits drug through different impermeable barriers, enhanced efficacy, and others facilitating passage in the cellular membranes.
[11]	"*Nanotechnology approaches for delivery of cytochrome P450 substrates in HIV treatment*"	Nanotechnology development for treatment of HIV can be considered through the preferential size of the "nanoparticles". Nanotechnology has been used in ARVs where formulation of ARVs may control nanoparticles release that will improve half-lives of the people suffering from HIV/AIDS. Nanotechnology can be further utilised in "***CYP substrates***" for HIV treatment in the initial stage.	Antiretroviral drugs (ARVs) have been metabolised through cytochrome P450 (CYP) where most of the drugs have been assumed to be CYP inhibitors and inducers.
[12]	"*Novel Nanotechnology-Based Approaches for Targeting HIV Reservoirs*"	HIV vaccine have been designed through "***lipid-based nanoparticle vaccine platform***" (NVP) presenting "***HIV-1 viral proteins***" for the responses between antigen-specific antibody. "***Liposomes-Based Delivery Systems of Ascorbic Acid***" has the potential to enhance bioavailability of the available ARTs used for treating HIV/AIDS.	The vaccine has the capacity for delivering "protein antigens and adjuvants" that may enhance immunogenicity through promoting the distribution of "protein antigens and adjuvants" towards antigen-presenting cells.
[13]	"*Nanoparticles and its implications in HIV/AIDS therapy*"	Some investigators have utilised "***Poly Lactic-co-Glycolic Acid***" (PLGA) for formulating nanoparticles that have been encapsulated within three ART drugs such "efavirenz", "lopinavir" and others.	The nanoparticle system has been witnessed to have produced a sustained release of the ART drugs for around 4 weeks and on the other hand, free drugs have been removed within 48 hours.

Table 2: Systematic Literature Review (Source: Self-developed)

Discussion

Lipid nanoparticles and "Liposomal AAR029b" Nano-based systems have been attuned for regulating the release of the medication whereas the nanotechnology needs both synthesis and also manipulation of the nanoparticles as substances. Liposomes have been considered to be vesicular carriers possessing two essential phospholipid layers along with aqueous nucleus. As liposomes consists of cardiolipin and synthetic phospholipids prepared through a procedure of ethanol injection. Therefore, such combination will have an influence upon the anti-HIV activity. Lipid nanoparticles help in enclosing indinavir that has been considered to be antiretroviral drug that tries to recognise CD4 co-receptor. "Immune-active nanovaccine delivery system" There is no such specific treatment to cure HIV or AIDS and this HIV infection leads to death in a 5-10 years period. Henceforth, lifetime treatment is used to improve the quality of health of HIV patients. However, HAART ("highly active antiretroviral therapy") or ART ("Antiretroviral therapy") has become very effective in the current treatment of HIV along with ARV (Antiretroviral) drugs as medications [7]. ARV drugs can be classified on the basis of the lifecycle phases of retrovirus. ARV drugs inhibit the lifecycle phase of retrovirus including entry, integrase, reverse-transcriptase, protease and

maturation.

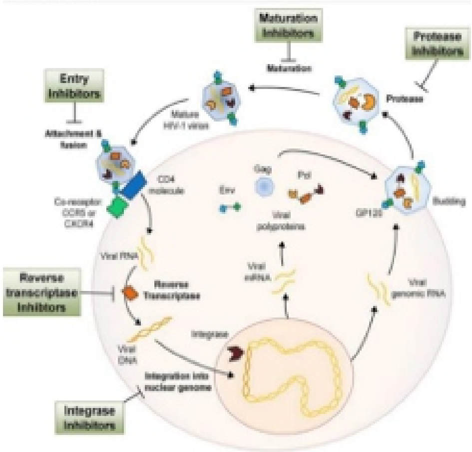

Figure 2: ARV drug against retrovirus life phases [7]

NSs have been widely used along with ARVs for the treatment of HIV as a potential solution in order to overcome the limitations of ARVs. It has been observed that niosomes, liposomes, solid-lipid NPs, polymers, nanohybrids and dendrimers are mostly used with ARVs [7]. NSs are utilised in HIV treatment for enhancing treatment efficiency, bioavailability and biocompatibility and minimising drug interaction with unrequired targets as well as toxicity. ARV involves specific issues including low stability, insufficient solubility, toxicity and undesired interactions. These constraints have been currently solved by utilising nanocarriers that have tunable properties, high ARV capacity, attached molecules and selective release property of cargo molecules. For instance, synthesised micelles of poloxamines are used with “encapsulated efavirenz” to maximise its encapsulation capacity sharply up to 8000-fold growth. According to [7], saquinavir loading efficiency becomes high up to 80% with the help of “chitosan-based NSs” (210 nm) which also increases the cell targeting capacity by 90%. Detection of “HIV-1 p24 antigen” through gold Detection of “HIV-1 p24 antigen” through gold nanoparticles HIV needs to be diagnosed at the initial stages to save human life by making patients cured. It has been identified that around 37.9 million people all over the world were diagnosed with AIDS in the year 2018 [8]. Most interestingly, the major proportion (79%) of people came to learn about their HIV-positive status in that same year. ART has become the most effective clinical access to get rid of AIDS; however, near about 23.3 million people have access to this highly-cost treatment across the globe. In this context, nanoparticles and nanomedicine play a constructive role in HIV treatment and thus it is promoted for having an effective impact on AIDS/HIV. Therefore, gold is used here to assess cellular uptake and biodistribution related to nanoparticles [8]. Moreover, the assessment related to biodistribution aids in analysing suitable in-vitro or in-vivo nanoparticle toxicity. As opined by [8], medical science discovers the utilisation of gold nanoparticles in detecting “HIV-1 p24 antigen” at early levels through BCA (“Biobarcode enhancement examination”) examination. It improves the detection of HIV at the initial stage and thus early ART treatment is possible to make patients healthier.

Nanotechnology drug therapies

Nanomedicine approaches have been employed in diverse systems on drug therapies or drug deliveries which include areas such as "vivo imaging", "in vitro diagnostics" and others.

Nanotechnology	Drug name	Author name	Reference
Liposomes	Stavudine	Maurya SD	Ref-19
	Lamivudine	Pai R	Ref-20
	Doxorubicin	James ND	Ref-21
	Zidovudine	Kaur CD	Ref-22
	Ritonavir	Ahammed V	Ref-23

Table 2: Liposomes nanotechnology for the development of ARV drugs [9]

The drugs that are encapsulated through liposomes have subsequently achieved therapeutic levels that can be further balanced through PEG gatherings within "synthetic phospholipids" [9]. Different medical investigators have been using this technique of liposomal encapsulation in a way to target the specific drug and act in the form of a curative promoter for those targeted organs. The names of the drugs (for examples, "Stavudine", "Doxorubicin" and others) that can be used with liposomes have been identified as the efficient drug therapy

Nanotechnology	Drug name	Author	Reference
Dendrimers	Zidovudine	Kumar s	Ref-26
	Efavirenz	Dutta T	Ref-27
	Lamivudine	Dutta T	Ref-28

Table 3: Dendrimers nanotechnology for the development of ARV drugs [9]

Dendrimers have been considered to be artificial macromolecules possessing characterised structures containing three components such as “central core”, “dense shell with terminal” and also “repetition branch units” [9]. Drug therapy through dendrimers has been appropriate because it has accurate polydispersity and size of nanometer has been permissible as well within the biological membranes. The drug names such as "Zidovudine", "Lamivudine" and others have been recognised according to the above table.

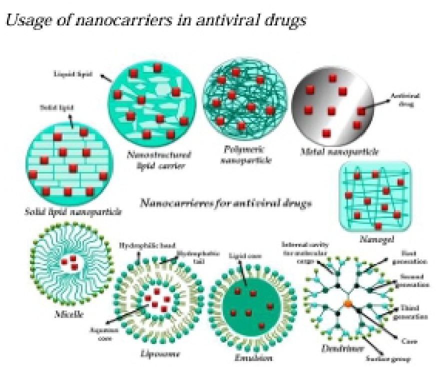

Figure 4: Development of nanocarriers following antiviral therapy [10]

ISSN : 2582-7405

Nanotechnology has provided the modalities for delivering the drug to pass through biological barriers, curb the circulation of drug levels and others. Nanocarriers with distinguished physico-chemical properties are effective drug therapy through nanotechnology for the treatment of the virus. The mechanisms within the "nanomaterial-mediated drug delivery" have been evaluated through its architectures and also particular properties of every nanosystem. The nanomaterials along with the nano-architectures have been utilised as HIV vaccine carriers and adjuvants that have already proved its capabilities.

Nanoplatform Type	Nanoplatform Characteristics (Size, Morphology, Toxicity etc.)	Drug	Virus Type	REF
	Liposomes			
- Reverse phase evaporation	• GCV mixed with PC/CH/NaDC dissolved in chloroform/diethyl; • Spherical liposomes; • Liposome sizes of 210 ± 17 nm, ζ-potential—32.4 mV; polydisperse;	GCV	HSV	[125]
- rHDL	• rHDL-nonlheptide complex with a diameter < 30 nm;	Nonlheptide	HBV	[126]
	• rDHL-ACV palmitate complex size of 33.5 nm, around 10 times smaller than ACV-liposomes;	ACV		[127]
- cationic	• Viral gene expression reduce by 65–75% in liver after 2 days of administration at mice;	siRNA	HCV	[128]
- immunoliposomes	• Viral secretion reduced by 81% and free viral particles neutralized in vitro;	HIV gp 120 Folding inhibitor	HIV	[129–131]
	• In vivo resistance to infection has been enhanced;	anti-CCR5 siRNA		
	• Immunoliposomes diameter with average between 100 and 120 nm; really useful to deliver high concentrations of indinavir;	Indinavir		

Table 4: Development of nano-delivery systems for various antiviral drugs [10]

The table is significant as the nanoplatform such as immunoliposomes can be used as drug therapy through the help of nanotechnology. The characteristics of the nanoplatform have been identified as well according to the size, toxicity and others. It has been witnessed that the viral secretion has been curbed by around 81% and also viral particles have been neutralised within the vitro. The diameter of the immunoliposomes has been "between 100 and 120 nm" and has been estimated to be beneficial for delivering indinavir in high concentration. The drug therapy will use a drug such as "HIV gp 120", "anti-CCR5 siRNA" and others [10]. Therefore, there is a high chance of curing HIV through this nanoplatform and these drugs.

Nanotechnology for delivering "CYP substrates"

Nanomaterial		ARVs	Size (nm)	Zeta potential (mV)	Entrapment efficiency (%)
Polymeric nanoparticles	PLGA	LPV	331.2	−13.8	45
	PLGA	LPV	142.1	−27.2	93.03
	PLGA	LPV, EFV, RTV	262	−11.4	45
	PLGA	NFV	185	28.7	72
	PLGA	EFV	200	−25	-
	PLGA	ETR	371.4	−21.0	91.0
	PLGA	MVC	331.6	−26.5	12.0
	PLGA	NVP	93–106	-	20–75
	PLGA	RPV	200	-	-
	PLGA	EVG	47	−6.47	-
	PLGA	EVG	190.2	−19.2	44.6
	CAP	EFV	96.9	−17.08	98.1

Table 5: Nanoformulations for CYP substrates used for treating HIV [11]

The nanoformulations have been prepared for preventing ARVs to overcome the impacts of HIV treatment. The formulation of ARVs is required to be enhanced to control the release of nanoparticles. Most of the protease inhibitors (PIs) (peptide-like chemicals) have been assumed to be CYP substrates in the form of "CYP inhibitors" and "CYP inducers". PIs have first-pass metabolism through "CYP enzymes" where there is a need for pharmacoenhancers such as “ritonavir” (RTV) or “Cobicistat” (COBI) to attain the therapeutic concentrations for the PIs [11]. In this regard, it can be stated that there is a development of various nanotechnology approaches only to overcome the limitations through PI regimens. Atazanavir (ATV) is selective and is considered to be an important inhibitor for HIV protease however; CYP3A4 has resulted in a decrease in ATV bioavailability. This limitation from CYP3A4 has been overcome through stearic acid that makes use of Pluronic F68 in the form of an emulsifier. Darunavir (DRV) is the most-prescribed PI used for treating people with HIVs however; these particular ARVs have been termed as poor for oral bioavailability [11]. In case, DRV has been administered by combining it with RTV then it may result in Drug-Drug Interaction (DDI) causing liver disorders as well as hypersensitivity reactions.

“Liposomes-Based Delivery Systems of Ascorbic Acid”

Nanocarrier and Targeting Ligand	Drug	Targeting Sites
	Liposomes	
β-d-1-thiomannopyr-anoside	Indinavir	Liver, spleen, and lungs [120]
d-mannose	Stavudine	Maintained significant levels in the liver, spleen, and lungs and overcame the development of anemia and leukocytopenia [121]
Galactose	Stavudine	Prolonged residence in liver and spleen [122]
Galactose	Azidothymidine palmitate	Liver [123]
Galactose	Azidothymidine	Prolonged residence in the body [122]
d-mannose	Zidovudine	Lymph nodes and liver [124]
Antibodies against human and murine HLA-DR and CD4 antigen	Indinavir	Lymph nodes, liver, spleen, and plasma [101]
	Nanoparticles	
Transferrin	Azidothymidine	Brain [125,126]
Mannan	Didanosine	Spleen, lymph nodes, and brain [127]
d-mannose	Didanosine	Lung, liver, and lymph nodes [128]
Trans-Activating Transcriptor (TAT) peptide	Ritonavir	Brain [129]
	SLN	
Transferrin	Saquinavir	Brain microvascular endothelial cells [130]
Bovine serum albumin	Stavudine	Liver, spleen, brain [131,132]
Dextran	Stavudine	Liver, spleen, brain [132]

Table 6: Anti-HIV1 drugs delivered to reservoir sites [12]

“Liposomes-Based Delivery Systems of Ascorbic Acid" has been witnessed to possess the potential for reducing oxidative stress and also prevent many chronic conditions of HIV. This strategy may assist during the time of oral administration of the respective ARTs [12]. In this scenario, there is a requirement for several researchers and also trials to evaluate the effect of vitamin C on the selected disease. The drug-loaded carrier based on nanotechnology has been found to help target anatomical along with "cellular viral reservoirs" that subsequently eradicate the virus from the sites of the reservoirs [14]. The nanocarriers provide drug therapy controllably that helps in incrementing bioavailability and also enhancing life quality among HIV patients [15]. The liposomes as drugs have been identified in the above table such as "Indinavir", "Stavudine", "Azidothymidine palmitate" and others that have been targeting different sites such as liver, spleen, lymphnodes and others

Formulation of nanoparticles through PLGA The preparation of “polymeric nanoparticles” (PNP) has earned great interest and success in biomedical science and research. It has been recognised that PLGA (“poly lactic-co-glycolic acid”) is used successfully in constructive “drug delivery systems” due to its low toxicity and high biodegradability. PNP can be formulated from PLGA of the size range 10-1000 nm through different methods including nanosolvent displacement, phase-inversion, solvent diffusion and emulsification evaporation [13]. However, nanoprecipitation and “emulsification solvent evaporation” are used the most to prepare PNP from PLGA. As per the studies of [13], the mixture of aqueous solution and a “non-water miscible solvent” is emulsified under the action of high shear force in the emulsification method. Thereafter, the volatile solvent evaporates and forms PNP; this method produces nontoxic nanoparticles with a rapid reaction rate. On the other hand, the nanoprecipitation technique involves a single step by using miscible solvents. This technique involves specific advantages such as adequate reproducibility, simplicity and low input of energy. It is important to eliminate potential toxic impurities such as surfactant extracts, organic solvents and polymer aggregates from the PNP after nanoparticle formulation. According to [13], gel filtration, ultracentrifugation, dialysis and evaporation are some crucial examples of lab-based purification methods

CONCLUSION AND RECOMMENDATION

The article has focused on the application of nanoparticle technology in drug therapy in terms of curing AIDS/HIV. It has been noticed that nanoparticle technology has become one of the most interesting fields in biomedical science. Fifteen authentic journals have been selected in this study to misconduct a systematic review in order to gather and discuss key information on the chosen topic. Liposomes are used for synthesising biodegradable nanoparticles such as “liposomal AAR029b” where “CD4 co-receptor” is used to recognise different nanoparticles that are used in ARV drugs. The process of nanovaccine delivery has been evaluated in this article with ART treatment. Furthermore, gold nanoparticles have been recognised as an effective biocompatible substance that can detect “HIV-1 p24 antigen” at an early stage so that treatment can be proceeded as soon as possible to cure patients. Along with this, the application of nanoparticles in antiviral drugs and drug therapies has been assessed in this article. Nanoparticles have been recently generated from CYP substances and PLGA that influence the application of nanoparticles in drug therapy against retrovirus and HIV. However, there is no such specific treatment for HIV that can completely cure patients. Thus, more research work and investigation named simulation need to be conducted to develop ART and drug therapy based nanotechnologies to improve the medical treatment against AIDS/HIV

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ISSN : 2582-7405

Implementation of Machine Learning (ML) in Biomedical Engineering

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ABSTRACT

The subfields within AI have been discussed throughout the article and the findings of the article have provided a positive outcome. ML has a huge potential through ML methodologies such as supervised and unsupervised learning as discussed in the article. However, supervised learning requires only labeled data while unsupervised learning has the potential to identify the hidden characteristics of the data. The clinical predictors that have been provided through "NN model" and "DT model" have the potential through determining the small datasets within biomedical engineering that further helps medical practitioners or healthcare professionals to decide on the medicine and treatment required for a patient.

Index Terms Biomedical Engineering, Machine Learning, ML Model, Nanoscale

I. INTRODUCTION

The research article encompasses two most important terms that are machine learning (ML) and also biomedical engineering where ML is a subfield within artificial intelligence (AI technology) where a machine is assumed to possess the capability of imitating human behaviour. As AI has already been incorporated within the healthcare industry and biomedical engineering revolves around applying the principles and also problem-solving techniques associated with engineering to medicine thus, there is a connection between ML and biomedical engineering. The main aim of the research is to implement ML within the field of biomedical engineering. Algorithms within ML have been trained to figure out different patterns along with correlations within datasets [1]. The datasets help in considering decisions and making predictions based on the results. The methods of deep learning have been utilised in medical imaging where algorithms in deep learning aim to run the data in several layers within algorithms of neural networks where each data passes through simple representation towards the next layer. Deep networks have helped in achieving best results as per recognition, prediction and classification of medical data where healthcare professionals have been able to cope with diverse complex problems that have been considered to be time-consuming, and difficult to resolve in reality. It is seen that biomedical signals have been utilised for designing and developing human interfaces, which is an evolving branch of biomedical engineering. There is a system that has been developed for people with disabilities that is a "hands-free head-gesture-controlled interface" [2]. This machine helps send messages and helps visually impaired people to manage travel aids. Two methods are used in the system where signals have been recorded through a accelerometer" while a "three-axis gyroscope" is used for calculating statistical parameters. The second technique revolves around analysing the signal samples that have been recorded through the "Inertial Measurement Unit" (IMU), which is an essential device for measuring and reporting gravity and also angular rate of a particular object. Pitch, immobility, yaw, and others can be evaluated thus, IMU sensors can be used within biomedical engineering. Medical imaging that includes “biomedical signal acquisition” is important not only within diagnostics yet in therapy as well to monitor the impacts [1]. The huge amount of datasets that have been generated through diagnostic devices has certain difficulties for exploration and in terms of analysing the data. The creation of “automatic data analysis systems” have been detected with various problems, which is the reason that the system has been implemented with different methods of ML. Thus, an automatic system cannot work alone unless it is supported by ML to further identify the complex patterns in large datasets. However, there are some issues with ML where sometimes ML fails to provide quality and quantity of data. Faulty programming through ML results in offering incorrect data where the accuracy of the results may get affected. There is another difficulty with ML as per generalising the data, which is a complex problem. The most important challenge for deploying ML is about understanding the ML systems and their related performance tasks as part of the inputs [3]. There is a requirement for using a sample of training data that represents new cases to generalise it. However, usage of non-representative training data may provide inaccurate predictions. Tendency of ML to capture noisy and also inaccurate data within the training dataset is a problem that requires an understanding of ML systems for deriving the results. The problem of overfitting within ML takes place because of utilising non-linear models utilised in algorithms of ML. However, this issue is resolved through linear and parametric algorithms.

REVIEW OF LITERATURE

ML and biomedical engineering

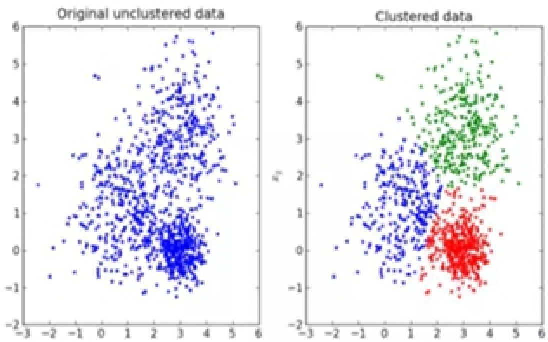

Figure 1: Clustered data [4]

ML is an essential subset within AI that has certain steps for the prediction of data that includes "data collection", "feature engineering", "data preparation and exploration", "model selection", "model evaluation", "model training" and others. [4] opined that the selection of the appropriate ML model is most important for figuring out the solution that also depends on the ML problem type that can be classified as "unsupervised learning", "reinforcement learning", "association rules" and others". "Unsupervised learning" can be categorised into two different types such as clustering and also association rules where clustering revolves around an arrangement of unlabeled data into similar groups according to the similarity and dissimilarities. Association rules figure out certain relationships among the essential points within the datasets where these points occur together within a dataset.

Biomedical engineering is a subset within the field of bioengineering that makes use of different practices within engineering for different healthcare practices through the help of designing various medical devices. [5] argued that engineered materials that have been used are biomaterials for therapeutic and diagnostic purposes. As biomedical engineering is a multidisciplinary field that uses concepts and design standards of engineering in medical biology for making advancement in human health. Therefore, the areas have been highly dependent on possessing knowledge regarding human anatomy and also physiology to provide solutions through biomaterial designs, which have been manufactured and integrated within the body to enhance tissue repair and tissue replacement.

ML in nanoscale biomedical engineering

ML has empowered biomedical engineering by optimising performance by modeling the data without much dependence on strong assumptions. [6] stated that datasets within nanoscale biosystems have been huge and complex for mentally parsing. ML has helped analyse as well as extract insights through enhancing the discoveries on the structures and materials for further supporting the communications and networks within nanoscale. There have been certain challenges identified in nanoscale biosystems that have been resolved through ML, especially through important categories. "SOTA ML methodologies" have been utilised in nanoscale biomedical engineering that further have been reviewed. One of the important challenges ("Structure and Material Design and Simulation") within material science is about understanding the structural properties. The complexities even become worse in terms of nanomaterials as these nanomaterials embrace various properties from components. These nanomaterials are assumed to be heterogeneous structures that consist of various materials.

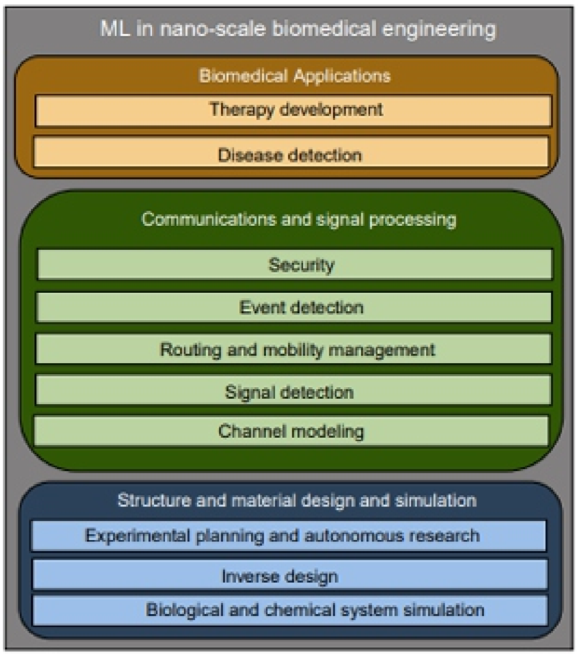

Figure 2: "ML within nanoscale biomedical engineering" [6]

The optimisation of structures and also materials after discovering the properties and behaviours through simulations and experiments have led to multi-parameters and multi objective issues that can be resolved through ML. ML aims to create associate configurations of atomic and molecular systems that will be performed through acquiring knowledge of experimental data. [6] argued that "communications and Signal Processing" is another challenging area where nano-sensors have been used for monitoring and detecting tasks. Size of those nanosensors has been around "1−100" nm, which has been referred to as macro-molecules and also bio-cells. Choosing the size and material is difficult in respect of system performance as constrained by target area, safety concerns and others. These nano-networks have been incorporated within the human body for communication with biological processes to collect information.

"Molecular communications" (MC)

systems may support those nano-networks through communications by terahertz (THz) band however, there is a need for a model for Thz communication among the nana-sensors for simulation and also for performance assessments. [7] opined that these nano-networks have a limitation in communication ranges and in processing power which can be resolved through ML where ML will offer tools for modeling space-time trajectories within nanosensors even within the complex environment of a human body. ML methodologies used in biomedical engineering are

ISSN : 2582-7405

"***unsupervised***" learning. The methodologies of "supervised learning" need labeled data for training.

The objective revolves around mapping out the input data for output labels. A mapping function "***(x)***" that can be increased through scoring function is "***f (xn, yn)***" where ***n ∈ [1, N]*** (n is the sample within the input data and *yn* represents label within *xn*, N is the size within that training data). "***Unsupervised learning***" methodologies figure out the hidden characteristics and also structures within the data without dependency on the training sets. [7] argued that these methodologies have been extensively utilised in discovering chemical and also biological properties within the nano-scale structures and nan-scale materials. However, there is a disadvantage of the methodologies as it is impossible to obtain standard accuracy of the output in the wake of absence of training datasets.

ML in wearable devices within biomedical engineering

Collection of biological data through wearable sensors which includes "***ExG signals***", "***electroencephalography***" (EEG), "***photopletysmography***" (PPG), "***speech signals***", "***surface electromyography***" (sEMG) and others have gradually resulted in the processing of complex and heterogeneous data. [8] opined that detection through human activity along with diagnosis and prognosis of various patients on account of manual investigation of those chosen data that has been obtained through sensors have been complex and also time-consuming. In such a scenario, there is a requirement for an intelligent system for decision-making whereas neuroimaging techniques that include "***structural magnetic resonance***" (sMRI), and "functional MRI" are a productive diagnosis of the disease. "***Magnetic Resonance Imaging***" (MRI) is an imaging technology that helps in the production of three-dimensional anatomical images in biomedical engineering.

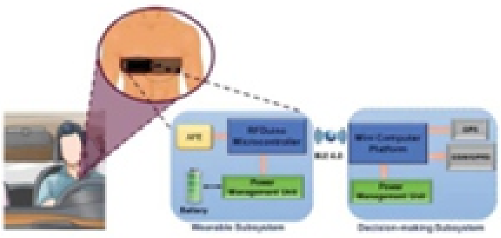

Figure 3: Wearable device [9]

Wearable devices have been prepared for various applications that include "***real-time detection of heart attack***", monitoring of blood pressure and others. ML algorithm diagnoses the patient's condition wearing those

The use of wearable devices can be better understood through an example where a "***wearable prototype system***" has been developed for monitoring the "***real-time heart attack***" through the help of two different subsystems. [9] mentioned that the two subsystems have been considered wearable subsystems and also decision-making subsystems according to the above image. "***Wearable sensor subsystem***" is found responsible for getting the signal acquisition, wireless transmission, digitisation and others of ***Electrocardiogram*** (ECG). In this aspect, ML algorithms have been trained according to the classification of ECG real-time where "***MIT-BIH ST Change Database***" has helped in identifying both the normal and the abnormal subjects.

METHODOLOGY

ML algorithms possess a "***degree of randomness***" within the training and also initiation routines. "***Random starting point***" has been assumed to be significant for enhancing convergence of the algorithms; however, there is a negative aspect of the algorithm stability and also on the generalisation that becomes pronounced with the availability of small training samples. The ML algorithm that has been trained for a small dataset will provide mismatched output patterns based on a random initial condition. The ML model also encounters erratic fluctuations according to performance [10]. Introduction of multiple run methods has the potential to offer means for comparisons between ML models enabling subsequent optimisation. Certain instances have been trained with the initial conditions. The ML model performance has been evaluated through different instances and not through a specific instance.

The optimal design has been evaluated through the comparison of the average performances of those runs within the ML models where individual instances are not able to be compared [10]. An optimal model has been chosen therefore, the performing instances of that design have been used in the form of a final model. ***Neural Network*** (NN) (subset within ML) have been used for predicting the "***Compressive Strength***" (CS) within the trabecular bone of the human body in terms of severe osteoarthritis through regression model while ***Decision Trees*** (DT) (supervised learning algorithm) have been used for predicting "***acute antibody-mediated rejection***" (ABMR) within the kidney transplants according to the pre-operative indicators through classification model. Application of both NNs and DTs shows that the strategy of selecting optimal models to obtain the best performance has been differing as the best performing instance of NN/DT has been chosen to be the predictive model. The comparison between various ML models through the utilisation of multiple runs provides a different result from using NN/DTs.

The size of the model run or the number of NN/DT model instances is influenced by the required balance between computational efficiency and expected performance

Neural encoding: It helps in understanding how signals from the brain or neurons react to the external variables with the tuning of curve analysis. "***Generalised linear model***" (GLM) of ML technology is widely used in successful "neural encoding" [11].

precision. More time and memory are required for the simulation of a larger run. It has been identified that maintained performance consists of the “minimum size” of runs up to three decimal points and the values are 600 for “DTs” and 2000 for “NNs” [10]

It is impractical to validate an ML model to operate regression tasks with a small dataset and concerning random effects. It has been observed that conventional methods including the "cross-validation approach" can be unreliable when there are limited samples of the independent test [10]. Therefore, it becomes crucial to go for an alternative approach to validate regression tasks through the ML models by considering the random effects of small data. Based on the success of the surrogate data in nonlinear and biomedical applications it has been proposed to use surrogate data as a small dataset for the validation of ML models in regression tasks. These surrogates generate from random numerals to interpret the distribution of the actual dataset for individual components of the “input vector”. In reality, the surrogate does not maintain the intricate interconnection between the variables of the original dataset when resembling real data according to standard deviation, mean and range [10]. Thus, effective “real-data models” are preferred to ensure significant performance compared to “surrogate data models”.

In this ML framework, the validation related to the “surrogate data” is assumed in terms of multiple runs. It is used for comparing the actual data of the “NN model” related to the “optimal design” with the NN model of the same design related to surrogate data co considering a run of “2000 NN instances”. The above experiment is replicated with 10 runs which involves a total “of 2000 NNs” for improving robustness [10]. This ML “regression model” can be tested and trained based on the surrogate data to create a benchmark to validate the “real data model”. If the “surrogate model” achieves the highest performance then a lower performance can be expected from the “real data model”. “Biomedical engineering” has developed significantly over the years due to the innovation and application of advanced technologies in the biomedical field. As a result, the study of neuroscience becomes much improved in terms of benchmarking and predictions. “Machine learning” (ML) technology has brought revolutionary improvements in neuroscience and neural coding which are going to be illustrated in the below section.

Neural decoding: Several standard ML approaches are used for “neural decoding” including the “linear Wiener filter”, Kalman filter, Wiener cascade (no online), and different neural networks [11]. However, the use of modern “neural networks” in biomedical science and neural coding has become the most effective ML approach in recent times.

Neural encoding: It helps in understanding how signals from the brain or neurons react to the external variables with the tuning of curve analysis. “Generalised linear model” (GLM) of ML technology is widely used in successful “neural encoding” [11].

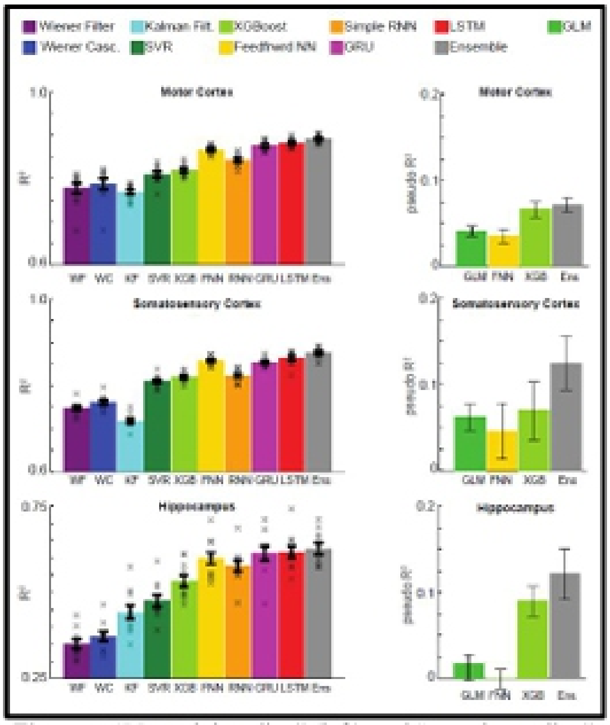

Figure 4: "Neutral decoding" (left), and "neural encoding" (right) [11]

Result

The small dataset has been possessing the features of the domain of biomedical engineering where complexity along with high expenses have restrained the availability of samples. It has been proclaimed that ML has the potential to provide an indispensable tool for biomedical problems containing heterogeneous data. The "NN model" has been designed to make predictions of CS within an "osteoarthritic trabecular bone" that has been obtained from "micro–CT indications" in respect of morphology, interconnectivity, patient's gender, age and others [10]. The dataset has been composed of "35 human femora" whereas the samples have been segregated as training samples consisting of 22 samples and validation based on 6 samples that have been utilising random permutation whereas the rest of samples have been considered for testing out 7 samples. The size and nature of the data have been considered where the NN model has been considered to be the base of the CS model possessing 5 input and 1 output features. 1*5 is the input vector where x has been stacked in a way that x1 = "Structure Model Index" (SMI), x2= "trabecular thickness" considered as Tb, Th, x3= "bone volume density" considered as "BV, TV", x_4= "***age***" while x_5= "***gender***" [10]. NNs have been trained by utilising "***Leverberg-Marquardt backpropagation algorithm***", the result in the form of NN model has been formulated mapping output as y in "MPa" towards the input vector "x" as follows:

$$y = \tanh[\bar{x} \cdot IW + \overline{b_{(1)}}\ ] \cdot \overline{lw'} + b_{(2)} \quad (1)$$

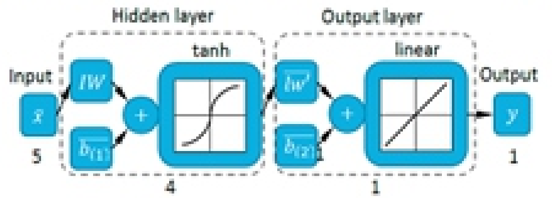

Figure 5: "NN model topology and configuration of layer of a 5D input vector"[10]

The above typology and layer configuration show that there is a hidden layer containing 4 neurons and also a single output as a neuron. Optimal NN has made a prediction of CS having "***root-mean-square error***" (rmse) as ***0.85 MPa***. However, factors on linear regression as R is present among "***actual and predicted CS***" have been around 99.9% within the dataset and also around 98.3% on those regression and classification tests. Real data on NNs have outperformed comparison with surrogate NNs in terms of a correspondence increase as presented as $\mu(R_{all})$ [10].

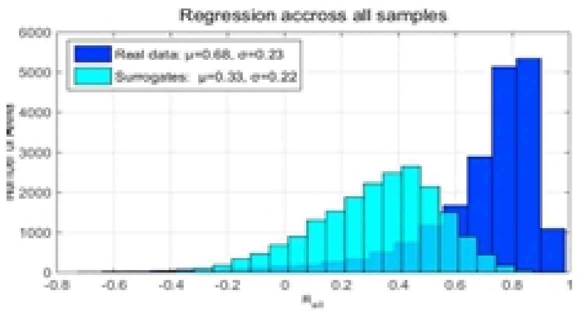

Figure 6: Performance of regression coefficients[10]

The outperformance shows a difference between NNs surrogate and "real data NNs" that is "from ***0.33 to 0.68***". p<0.000001 is statistical significance that has been achieved where the median value for $R_{sur,\ all}$ has been around 0.38 as per surrogate NNs while median value for $R_{real,\ all}$ is 0.78 according to real data NNs [10]. In this respect, surrogate threshold is assumed to be a surrogate model on high performance that has eventually exceeded the "optimal real-data NN model".

Model	Performance measure	performance on data subsets			
		training	*validation*	*test*	*all*
NN	regression, *R*	0.999	0.991	0.983	0.993
DT	classification, *C*	0.867	n/a	0.850	0.862

Table 1: Performance measurements from NN and DT (ML models) [10]

Conversely, "***optimal DT***" model has been achieved through classification accuracy where C has been assumed as 86.7% in the wake of training phase and accurately classified as 85% within test cases. The results show that DT model has recognised ***ABMR+ve patients*** with around 88.9% sensitivity along with ***ABMR-ve cases*** possessing 82.9% specificity [10]. HLA DSA antibodies where DSA stands for "Donor Specific antibodies" is an important concept associated with transplantation medicine and eventually describes antibodies in Donor's HLA-Molecules. These antibodies are a contraindication opposed to transplantation in several cases [12]. Furthermore, "***HLA DSA antibodies***" have an association with ABMR+ve/ABMR-ve classes. The DT model has identified that patients possessing an increasing level of "Mean fluorescence intensity (MFI) Donor Specific Antibodies"MFI DSA that is below 834 therefore, belong to "ABMR-ve group" however "***igg_hi ≥ 834***" and "***igg4 ≥ 36.5***" possessing a likelihood towards transplant reject at an early stage. Simultaneously patients possessing a mismatch of around 4 or 5 HLA molecules diagnosed with "ABMR+ve group".

Discussion

The compressive strength within certain trabecular tissue within the femoral head indicates risk from bone fracture that has affected around 20% of cases in the orthopaedic hospital. The "NN model" has been related to biological as well as structural parameters that offer the output values for the specimen CS. The "NN model" has been successful to map out the 5-dimensional input in the wake of a continuous CS vector possessing an accuracy of around 99.3%. Regression coefficients among the actual and also predicted CS values have been determined through test samples that are 98.3%. Identified 5 biological and structural indicators (such as SMI, trabecular thickness, age, gender and others) have been evaluated from the scans of computer tomography providing an opportunity for nondestructive estimation of fracture risk of trabecular tissue [10]. This driven model on patient data for CS estimation can easily be utilised by engineers associated with hard tissue for designing "bioscaffolds" imitating trabecular bone.

These bioscaffolds or scaffolds have been assumed to certain substitutes for bones that have been prepared from "***poly(lactic acid)***" (PLA) that have been assumed as the substitute materials for bone [13]. Bioscaffolds have helped make clinical decisions especially for diagnosis and potential treatment for osteoarthritis patients. However, the "DT model" has acquired an accuracy of around 85% for predicting ABMR within renal transplantation. There have been around 92,844 patients who have been recorded as compared with availability of 80 samples for this "DT model" possessing high-performance in terms of short-term rejection. The "DT model" predictions have an indication that has been associated with patient-specific concerns [10]. The prediction is made based on the clinical indicators where those indicators are either known prior to the surgery or in the period of post-transplantation. The model is helpful as it offers predictions as per "ABMR risk stratification" moving towards individual transplantation. In addition, it can be stated that within the domain of clinical and biomedical engineering, these predictive models of ML have helped map out the input and output patterns [14]. The techniques on multiple runs in the tasks of regression and classification conform to the fact that size of the dataset does not limit the use of ML-based methods within the biomedical domain. The accuracies that have been derived through NN and DT models on the 35 samples have been compared further with some high-performance models of ML that have been designed on huge datasets in correspondence with biomedical applications [15]. The high-performance models of ML may include "Support Vector Machine" (SVM) or others that have helped predict hip fractures within n osteoporosis, risk patterns associated with genotype- phenotype in a patient suffering from diabetes and kidney disease

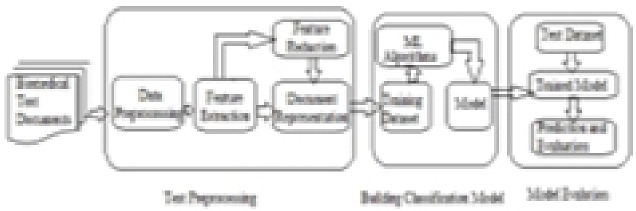

Figure 7: Classification process within the biomedical text [16])

AI technology is applied in both medicine and healthcare and has undergone a regulatory analysis along with clinical adoption. The data that have been used for training the algorithms have also undergone scrutiny [16]. The biases and pitfalls within the algorithms can easily be understood and determined where it has been further found that trained algorithms with biases typically possess biases and thus fail in case of deployment in a setting that is different from trained data that has been acquired [17]. However, extreme dependency of AI-driven diagnostic models on historical data has been assumed to be not capable of diagnosing the phenotypes where patients have earlier suffered from a stroke and have also shown coronavirus symptoms. The segregation of various biomedical literatures within biomedical engineering is a cumbersome process where automatic text of biomedical documents consists of modules such as text processing, model evaluation, and others [18]. Input within the module of text processing contains raw biomedical documents and valuable words and characteristics have been extracted to obtain an appropriate format with the help of well-defined methods of processing.

CONCLUSION AND RECOMMENDATION

The article is important as the article has emphasises a significant relationship between the adoption of ML models within biomedical engineering. The issues of using ML have been identified where it has been found that ML sometimes fails to offer quantity and also the quality of data. Therequirement of training data is one of the most important aspects of ML implementation that has been identified within the article. Different significant aspects have been evaluated where it has been seen that nanoscale biosystems have been [prepared through nanomaterials that are found to have different properties. These nano-networks have been seen to be incorporated within the human body to collect important information. The result from utilising NN and DT models have been assumed to be accurate for curing bone diseases in osteoarthritis and also kidney transplantations

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ISSN : 2582-7405

Advancement of the Internet Of Things (IOT) and Point Of Care (POC) in Biomedical Engineering and

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ABSTRACT

This article is based on the advancement of the point of care and the internet of things in the healthcare system and biomedical engineering. This study has mentioned the advantages and benefits of the POC or point of care and IoT and the internet of things in the healthcare system and biomedical engineering process. From this study, it has been seen that, internet of things develops the process of treatment and it makes a huge impact on the technologies. Nowadays, medical professionals are using various kinds of gadgets and devices that help to track the patient's movements and recognise the disease easily. These kinds of devices are made up of high quality and updated sensors. Hitech quality software and premium quality sensor, strong hardware and high process chip help to recognize the frequencies, or body activities such as blood pressures, heart rate and others. This technology has some limitations that hamper confidential data and that is why it is required for high-protected data security processes. Advancement of the POC also makes an impact in the drug management also. Accordingly in biomedical engineering process gives the opportunities to take a high-power networking system that helps to get the actual and desired result from the technology. Point of care and the internet of things both are interconnected with the system and it makes a major impact on the field of the biomedical engineering process. At last, it can be said that, point of care applications internet of things make a renaissance in medical world.

Index Terms Chip, Devices, High-Capacity Sensor, IoT, Monitoring, Silicon Sensor, Updated Software

I. INTRODUCTION

IoT or the internet of things explains the network as a physical object and is embedded with software, sensors, and also other kinds of technologies. The main purpose of the IoT is to exchange and connect data with other different types of systems and devices through the internet service. There are 4 kinds of IoT networks such as cellular, personal and local area network, mesh network, and LPWAN, or "low power wide area networks". IoT is the process that assists to connect each and every physical object by using the internet and it is much more user-friendly and controllable also.

POC or point of care is one kind of application that is based on the IoT and this application provides the opportunities to observe and monitor the entire healthcare system. On the other hand, these modern technologies also help to provide the facility to keep the patient safe and healthy. Accordingly, it can be said that in biomedical engineering, POC and IoT play a major role and also impact the innovation process also. This study will highlight the advancement of IoT and POC that allows various opportunities to develop the healthcare system and medical engineering process. Moreover, IoT and POC provide exceptional benefits and the system provides zero error outcomes. This kind of application allows the physicians to empower them and also provides a high level of satisfaction to the patients. On another hand, it increases patient engagement and makes an outstanding impact on medical engineering. Accordingly, it can be said that point-of-care applications also contrite some space in the surgical sectors. This study will try to highlight on the entire system process and also discuss the Internet of Things and point of care and its relation with the high range of devices and gadgets. On the other hand, there are various kinds of sensors and other technologies that help to improvise the process of working such as data transformation, collecting data from the various processes or sensors, and also recognizing the solutions for hardware and software. From several studies, it has been seen that artificial intelligence makes a wide range of transformations in medical engineering and it also includes the diagnosis of disease, predicting patient prognosis, determining the optimal treatment, and inventing advanced devices that help to make improvements in the medical field. This study will shed light on the impact of IOT and POC in the healthcare system and medical engineering process.

LITERATURE REVIEW

Connections of IoT and POC with biomedical engineering and healthcare

Internet of things and IoT are interoperate with multiple fields and also interconnected with various kinds of industry such as healthcare, medical engineering, and others. In the modern era, medical devices are essential for patients and all medical professionals. It provides various opportunities that help to diagnose the problems and patients easily. Accordingly, there are various applications that provide the facilities to monitor the patients and their bodily reactions through technology and devices [1]. POC applications basically run through the internet of things. It is able to exchange and transform medical data and also participate in improving the quality of life of a patient. Moreover, this kind of application all makes a huge impact on the surgical sector also. In modern days professionals use many kinds of robots and surgical tools that are based on the IoT. These kinds of tools are able to connect with other devices or systems. It assists to improve the work and production flow with zero human error and these applications are easier to use [2].

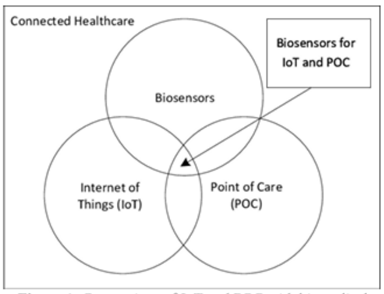

Figure 1: Connections of IoT and POC with biomedical engineering and healthcare [3]

Accordingly, point-of-care technologies and applications have their own network system that helps to connect all the data and also provides the logical conclusion or result for the process of working. In the medical engineering process, POCT works in a systematic way, and in the human intervention process, POC plays a valuable and versatile tool. The medical engineering process uses various kinds of principles that can solve and improve healthcare opportunities. POC application helps to make life safer and healthier [3]. There are various applications such as IoT asset monitoring, wearable IoT devices, remote monitoring, bed, and patient monitoring, and surgical devices such as robots, gadgets, frequency readers, and others. The medical professionals use Ai technologies and various IoT devices that help to track and monitor the patient's health conditions such as blood pressure, glucose trackers, and asthma monitors. Nowadays fitness watches are an innovative concept of medical engineering that helps to track the heart rate, body temperature, and other movements of the body. It also connects the smart phones with the watch that provides the daily health status by using IoT applications.

Impact of IoT and POC in biomedical engineering and healthcare

As mentioned previously POC is an application that helps to track the body function and also is able to monitor the patient's healing and record. The internet of things and point-of-care technologies are interconnected and it helps the patients to diagnose the issues and threats quickly. In other words, it can be said that in modern days this application improvers the treatment process and also makes a huge impact on the patient and medical [4]. These applications used some high-quality and effective software and sensors that helped to track the hospital, patient records, and movement of the patient. In order to easily recognize the issues, the medical professionals use updated technologies so that they can begin the treatment process easily.

Figure 2: Gadget and Devices [5]

This application uses various circuits and high-range sensors such as interdigital sensors that help to get the actual or desired outcomes from the system. On the other hand, there are different kinds of analysis tools that help to analyse the data and also monitor all kinds of operating principles [5]. There are some applications that use silicon sensors due to their high sensitivity. Electrochemical biomedical uses a small chip that is one type of point of care. It can change the sophisticated and costly laboratory system. In the field of clinical diagnosis, POC technology helps to create access to the application. Some kinds of POC devices carry a real-time testing process that helps to provide the exact outcome of the process. In the healthcare system POC devices make a huge impact to access the health and patient-related data [6]. In this context, it can be said that cloud service and wireless transmission server allows transmission and sharing of the measured data as per the requirement. On the other hand, with these kinds of technologies, it supports and enhances the sensing system to monitor the patients through the internet of things. POC technology reduces the diagnosis cost and provides real-time information that makes a positive impact on the process of treatment.From several studies, it has been seen that silicon-based sensors generally integrate into microfluidic systems with the 3D printing system. IoT process also gives a large amount of storage capacity that is highly required for storing the data and transferring the data to the end users [7]. On the other hand, biomedical applications are also able to measure the different kinds of conclusions and also find out the pathological report that is more essential for the medical sector also. IoT and POC technology make a huge impact on the medical engineering process and upgrade the system of healthcare also [8].

Figure 3: IOT Related gadgets [9]

These kinds of gadgets and applications empower the patients and medical professionals so that they can also make positive effects on the work process and increase the working capacity. At last, it can be said that POC and it gives a high number of benefits that make a modern impact on the medical grounds and it improves the psychology of individuals. Accordingly, IoT technology provides various kinds of opportunities such as it can predict the chronic disease and also make an impact on the drug management and keep the tracking of hardware maintenance.

In the medical sector there is various equipment and it is not to maintain all the things for the employees or staff. The IoT system allows to maintain all the equipment and generate the database. It helps to reduce the breakdown risk and helps the medical sectors to arrange all the things in the crucial time. On the other hand, this facility also improves the tracking capacity of employees and patients and their movement [9]. Accordingly, drug management is a process that is interconnected with the medical sectors. With POC and Internet of Things devices patients are able to receive real-time alerts and also generate bills and other necessities from their Smart phone.

In the genetic engineering process, the engineers use various kinds of chips, sensors, and updated software that increase the provision of high storage capacity of sensing power and it also controls the temperature and tampering protection.

Challenges of IoT and POC in biomedical engineering and healthcare

In technological advancement, there are various kinds of limitations and challenges that cannot be ignored. There are various kinds of challenges on POC and IOT in health care and biomedical engineering process that are listed below: Data Security: In the medical sector one of the biggest threats is data security and privacy. There is a large amount of health-related data and this system stores, transmits and shares a massive amount of data on a regular basis [10]. In this context, hackers create fake accounts and also hack all the data and so buy medicines and drugs for misuse. In medical industry, there is a huge amount of confidential information about patients and drugs. This technology has a greater chance of data breach that makes a huge impact on the society and entire medical and health system

Protocols integration: POC applications and devices always connect with multiple gadgets or devices and all the systems require various functionality and protocols. In this context, there are not any kinds of single solutions to maintain and communicate all the standards and protocols [11]. In order to create medical software, the producer needs to maintain the Hitech and HIPAA complaints. These protocols are able to contain various kinds of rules and regulation that helps to protect the data from a breach.

Data overload and Accuracy issues: IoT healthcare devices or POC applications process and collect a lot of information on a daily basis. Medical professionals face accuracy and issues in their process of working. On the other hand, the health care applications also create various difficulties in the decision-making process during the process of treatment [12]. Sometimes this technology is not able to provide the accurate information, and it is responsible for an incorrect diagnosis. In addition, the devices and sensors are always not accurate and it can have incomplete and mismatched data sets.

Cost: From this study, it has been seen that IoT can reduce the cost of treatment, and all. Though, all hospitals and companies are not able to afford the IoT system. It has a huge amount of implementation cost that makes an impact on the economic portion of the medical sector. That is why implementation cost is the major factor on the biomedical engineering. On the other hand, sensors, parts, gadgets, or devices are more costly, and it makes an economic impact on the field of biomedical engineering.

Conceptualization of futuristic approaches for IoT and POC

IoT has lots of opportunities that may develop treatment process in the medical sector. From various research, it has been seen that many IoT healthcare companies try to introduce new ways of working with technologies that improve the medical world [13]. POC and IoT has some particular limitations and challenges though it will not stop the up gradation and it can help the industry also. On the other hand, in the future, this application and technological process helps doctors to connect with patients worldwide. Patients are able to take the advice and suggestion from doctors from any geographical location. In the modern era, this technology is able to reduce the time and cost of diagnosis. In the future, the IoT system and POC are able to improve the entire functioning capacity of medical doctors and the automation process will also make an innovative impact on the future medical department and also provide a smart environment to the future generation. From this analysis method it has been seen that the internet of things and point of care may improve the future treatment process. It helps the individual to get the treatment at the right time and right situation. Accordingly, it also increases the rate of recovery of the patient and the applications of the technologies also help the medical professional to increase the rate of solutions of major problems. This factor helps the next generations and individuals to take the technological and first treatment procedures for their family and own.

METHODOLOGY

This study used a secondary qualitative method to get the desired outcome from the study. This research has used the existing data that helps to get various kinds of advanced information about the internet of things and point of care in the medical engineering and healthcare system [14]. This research study uses previous and ethical data to recognize the answers to the research question. The secondary process of research uses the data that was previously gathered and is also previously accessed by the researchers. This process of research and process of data collection is much easier than other processes of research and process of data collection. In this research, process observation is the fundamental key. It helps to notice all the things that help to gain knowledge for further research.

Accordingly, it provides the provision to make a difference between observation and previously collected data. This process of collection of data uses novels, newspapers, journals, government reports, magazine, radio, and television outputs [15]. It helps to provide the authentic data for the study. On the other hand, secondary qualitative data collection methods provide a heavy large amount of data on the subject matter. This process has a technique that helps to extract the data from a large amount of data. On the other hand, it also assists to recognize the relevant data from the data set. In addition, the secondary process gives a clear structure to the data set that makes a positive impact on the analysing process. Accordingly, it provides the provision to interpret the data and this is cost-effective due to this process not requiring outer study. On the other hand, this study does not require a high amount of technical skill [16]. It is one of the biggest advantages of this research process and the other benefit is this process is more time-saving. On the other hand, it saves expenses and efforts that assist to finish the research with interest and great effort. In addition, it provides a fine analysis process of data from the data and samples. Furthermore, this process helps to understand the physiological status of the author and gives the chance to gain depth knowledge on the subject matter.

DISCUSSION

From the above-mentioned study it can be observed that internet things refer to the network as a physical object and it connects with the sensors, software, and other different kinds of technologies. The actual purpose of the IoT is to connect, collect, and transfer the data in different kinds of systems and devices that attach the devices and gadgets through the internet connection. From this study, it can be said that IoT is a crucial process that can assist to attach an invisible connection with every physical object through the internet. This is user-friendly and more controllable than other processes and it helps to provide a suitable pathway for creating the innovation [17]. On the other hand, biomedical engineering creates various innovative things that help to check the human physiological condition and it also makes an impact on the healthcare system. From this study, it can be recognized that there are some crucial connections between IoT and POC. POC application helps health professionals and individuals to take a record of their physical condition and monitor their health by checking blood pressure, glucose, heart rate, digital thermometer, and many more. It has been seen that these kinds of gadgets and devices also transform medical data and make a huge impact in the surgical sector. Nowadays robotics is one of the innovation processes that play a significant role in the surgery [16]. Individuals also try to adopt this process of surgery on their bodies. This technology has various facilities such as it can provide the actual data set, and transfer the data as per requirement. Accordingly, this process has a zero percent human error solution to proceed with the surgical process. Accordingly, bio-engineering technology uses a variety of sensors that helps to catch the high and low frequencies of the body. In addition, it can be said that point-of-care application and technologies have their own network system and it helps to connect all the data. On the other hand, IoT has the capability to maintain the data as per the data patterns. This is a huge resource of information and data that help individuals and medical professionals to use in their innovation process. In the aforementioned study, it has been seen that POCT works in a much more systematic process and it also makes a huge impact on the biomedical engineering process [17]. In the field of biomedical engineering, there are various sensors that use by the artificial intelligence technologies. It provides automation facilities and it also can measure real-time data as well.

The internet of things and POC application helps medical professionals to recognize diseases and difficulties in a short time by using of various kinds of circuits and different kinds of sensors. From this study, it has been seen that each and every tool has its own operating principles and also improves the hospital and employees' arrangements. Biomedical engineering provides facilities to the hospital authorities and also tracks the employee record and performance also through the help of the internet of things. From this article, it

has been seen that technologies have different kinds of challenges that make an impact on the entire healthcare system. Data security is the major thing in the healthcare industry, there are different kinds of confidential data that helps with the purpose of treatment [17]. In the hospital industry, millions of data are transferred in a single day, it requires a high-security process of the data. Accordingly, POC applications ad devices are also attached to the different kinds of gadgets and devices. all the devices have maintained the significance protocols that an expert to communicate with other kinds of devices. The other major problem is cost and individuals are not able to afford the gadget to communicate and maintain the HIPPA, AND HITECH complaints. On the other hand, POC and IoT healthcare devices and applications process can able to generate lots of information and also face issues related to IoT technologies. Every POC and IoT has some particular limitations and challenges though it will not stop the up gradation and it can help the industry also. the IoT system and POC are able to improve the entire functioning capacity of medical doctors and the automation process will also make an innovative impact on the future medical department and also provide a smart environment to the future generation

CONCLUSION

From the above study it can be concluded POC and the internet of things in the healthcare system and biomedical engineering and it can able to make a huge improvement in the medical industry. In the field of the biomedical engineering process, there are various kinds of factors that can improve the entire procedures of treatment and it has made a sophisticated platform in the medical field. There are various devices that are made up of high-quality and updated sensors and advanced technologies that are able to track the frequencies and other measurements such as glucose, blood pressure, and heart rate. Medical professionals also use the gadget to recognize heart conditions, brain conditions, and frequencies of nerves and also find the pathways of the neurons their signalling process. IoT is the process that assists to connect each and every physical object by using the internet and it is much more user-friendly and controllable also. IoT and POC provide exceptional benefits and the system provides zero error outcomes. It can be said that point-of-care applications also contrite some space in the surgical sectors.

Medical professionals use Ai technologies and various IoT devices that help to track and monitor the patient's health conditions such as blood pressure, glucose trackers, and asthma monitors. These machines used high-quality and effective software and sensors that assist to keep records and track the hospital, patient records, movement of the patient, and many more. cloud service and wireless transmission servers allow the transmission process and sharing of the measured data. IoT and POC technology make a huge impact on the medical engineering process and upgrade the system of healthcare. POC and IoT also make a huge impact on drug management is a process that is interconnected with the medical sectors. Patients are able to take advice and suggestion from doctors from any geographical location. This study has used a secondary qualitative method to collect the data and it provides the provision to interpret the data and this is cost-effective. On the other hand, it also helps to gain more knowledge on the subject matter. At last, it can be said the IoT and POC can be blessing for the whole health care system and biomedical engineering process.

RECOMMENDATION

- Medical sector needs to implement industry 4.0 which helps to improve the patterns of treatment efficiently
- Medical industry should use new technologies that assist individuals to gets better facilities and care for the welfare of the patients

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