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Internet of Medical Things - Applications in health care system

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Abstract

Internet of Medical things (IoMT) provides communication between health care components for the improvement of patient's health. IoMT can be applied in various fields including Artificial Intelligence (AI), biomedicine, and most commonly in medical science and also in medicine. Different kinds of analysis and techniques are applied through secured procedures in the field of telemedicine. The main objective of this article is to highlight the applications of telemedicine and the internet of medical things in medical and health care. IoMT has a lot of applications regarding medical and health care system like the detection of many diseases and providing effective treatment to patients. The use of IoMT in the field of telemedicine certifies the safety of the organization, the capacity of active loading, secure and protected actions of the organization. However, due to the expository nature of various health care systems, a lot of challenges are faced by the internet of medical things. These challenges include reliability, accuracy, safety and security.

Keywords: Internet, Medical, Telemedicine, Privacy

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1. Introduction

The term internet of things (IoT) was first time coined by a private organization and the implementation of IoT in health sector technology in health care and medical domains is acknowledged by way of the internet of medical things (IoMT). Internet of medical things is founded on devices and systems with durable customary internet methods. Its rationale is the creation of reasonable web systems so that manifold varieties of resources and medical facilities are interrelated with the assistance of these internet-based machines. The significance of IoMT is highlighted by its role in far-off areas. Healthcare and medical sectors have been revolutionized owing to IoMT models [1].

IoMT is also known as the health care internet of things. It includes an assembly of health tools and software links. Maximum number of health care persons utilize IoMT based computer programs to optimize diagnosis, in constraining disease spread, in improving client provisions, and management of medicine, especially in context of Covid-19 pandemic [2]. Machines are connected in IoMT wirelessly to transfer data. It has been studied that IoMT based health structure amended the daily life of patients as it is economical, user-friendly and also increases the awareness of consumers. Furthermore, IoMT provides efficient rescheduling of inadequate resources with optimal usage and facilities provision to incoming patients. These devices are connected with cloud for effective storage and analysis of data [3].

2. Types of IoMT in healthcare

1. Diagnostic IoMT
2. Drug advisory IoMT
3. IoMT for education of healthcare staff and patient
4. IoMT for communication among all stakeholders

2.1. IoMT Communications

Instantaneous data transfer between relevant components of medical devices proceed through four network systems that are BAN (body area networks), HAN (home area networks), NAN (neighborhood area networks), and WAN (wide area networks) [4].

2.2.1. BAN

A portable sensor measures the signals from patient and its transmission is done by BAN. Biomedical signals provide protection to such communication [5]. Low power bio-identification procedure is offered using IPI (inter-pulse interval) to shield the messages among BAN device sensors (Fig.1). The records compiled are sent to the supervisor by diverse binary approaches such as:

- **Smartphones:** Patient data are conveyed to the health care facility.
- **Wireless apparatus:** Records are communicated with manifold wireless etiquettes [4].

2.2.2. HAN

In this type, a supervisor controls whole process of data transfer. Information is transferred to an access site in home of diseased person. LTE (long-term evolution) 4G network or Wi-Fi are used for this purpose [6].

2.2.3. NAN

NAN creates simple user admittance so that internet connectivity becomes very fast between household and homes in vicinity. An individual AP (access point) can accomplish the range of about half a mile.

2.2.4. WAN

WAN involves messaging concerning the AP and medical set-up. Through any emergent situation, actual data is conveyed to the emergency crew and for storage; it can also be transmitted to cloud services by AP [4].

3. Telemedicine or Telehealth (Teletherapy)

Telemedicine has several categories. Patient can have physician's advice through messages or appointments for checkup are taken (Fig.2). Telemedicine means integrating the IoT such as a fitness wristband, heart beat checking devices, and artificial organs transplant machines. Smart patient beds can evaluate heart-beat, body temperature, blood pressure and pulse rate of a person and can send alarms during any emergency condition [7].

Network models allow the medical personnel to link with patients by wireless practices and physician can do checkup and communicate with patient. Networking systems are used for information transfer, while for linking the sensors to check heartbeat, temperature measurement, humidity measure and alcohol level, GSM (global system for mobile communication) and bluetooth are widely utilized [8]. For any emergent situation, system has default setting for provision of medical help. Along with it, various varieties of Wi-Fi and GSM segments are also engaged [8].

4. Structure of IoMT

Five layered framework consists of presentation, integration, service, analytical data and the data.

1. **1st (Presentation):** Diverse machines with several sensors and conventional internet facilities (phones, computers).
2. **2nd (Integration):** Vital constituents present are the data loading systems along with the interrogation systems.
3. **3rd (Service):** It comprises of cloud, IoT, organization of probing practices.
4. **4th (Investigative data):** It consists of CVI (critical variable identification) facilities, and endorsements related to medical field.
5. **5th (Data):** It contains diverse databases for monitoring, vital variable, history of a person along with therapeutic recommendations.

After data collection, all patient relevant information is transferred by wearable sensor aids. Body temperature, calories used, stages of treatment conducted and heartbeat are evaluated. Then it is send to the next section for the collection of question in next phase and information collected is translated. In this layer statistics from the database, which is the part of the data layer, is demanded by the query formulator. Link between query selector and analysis procedures takes place. After referring to data layer, the patient's statistics are scrutinized by the CVI for inspection whether all the factors fulfill the standard collection or not. It detects emergency relevant to the diseased person and interaction of CVI with IoT components for provision of support reliefs like ambulance. Then location and medical history of the patients is conveyed to health care persons [9].

4.1. Uses of IoMT

Wide range of IoMT uses in health care sectors exists. Different types of automatic detectors for breast cancer, cancerous lung nodules, to monitor chronic diseases progression, and management are available. Diversified applications are in use and mode of application is either single or clustered. Diversified single application can be applied for a specific disease, or clustered applications are used for several diseases. The IoT uses are sensitive healthcare processes as these have confidential data of patients such as names, current disease status, and their location.

4.1.1. Single applications

- Evaluation of glucose level by glucometer and gluco-watch
- Assessment of heart functioning by electrocardiogram (ECG) device
- Blood pressure measurement by sphygmomanometer
- Body temperature assessment by oral, tympanic, forehead, basal and pacifier thermometers
- Measurement of the oxygen saturation levels by fingertip pulse oximeter blood oxygen monitor

4.1.2. Clustered applications

- Rehabilitation process
- Management related to different kinds of medications
- Arrangement of wheelchair and other assistive devices (crutches, canes, walkers, hearing aids, prosthetics etc.)
- Foreseeable healthcare issues
- Solution for health care by iphone or android applications using cloud

Since the last few years, there is an influx of vast range of health care assisting aids in market that rely generally on the sensors, as certain imperative information of patients is processed by sensors, and then data is shifted to concerned quarters. Sensors offer many benefits to physicians and patients. They can gather information related to patient's health; the blood pressure, blood glucose levels and body temperatures and sleep patterns [9]. Salient benefits of IoMT are presented in table 1. Since the past decade, the internet use was restricted to the transfer of data only. The devices of intelligent fitness could be used only upon the will of user that was patient to collect relevant data. (Fig.3). The collected information is analyzed by multiple IoMT appliances [10].

Heart diseases lead to elevated mortality rate and these arise from the blockage of the arteries or valves, and by pulmonary complications. Heart diseases are not similar to common cold or fever in which a person is infected through airborne or by other routes. Earliest possible detection can increase chances of better remedial options and for this purpose, IoT is merged with machine learning (ML) procedures. Management of patients is possible in far and distant regions with the help of IoMT innovative practice of constant tracing. Detectors perform data verification that is taken and at that time forward it to the particular consultants. By the assistance of caregivers, the physical condition of the patient can be checked and if required, they can contact physician [11].

5. Algorithms

5.1. Random Forest Algorithm

Scientists utilized several algorithms for the forecasting of heart problems. Statistical models with heart rate variability input with two diverse output groups. Variables like specificity, accuracy and pliability were tested via these models. Accuracy results obtained by RF (random forest) algorithm were 93.61% [12].

5.2. ML Algorithm

ML algorithm detection process for heart diseases was used on two data sets. About 95.25% and 92.15% accuracies for both sets were achieved [13]. Contrast among classification and regression was conducted to forecast numerous clinical procedures during cardiac arrest. Previous data (Framingham study) was used for the investigation. It was observed that using these algorithms, prognostic as well as diagnostic capability of regression techniques was increased [14].

A forecast system was established with joint classified methods for the assessment of aspects responsible for increasing the hazard of cardiac diseases [15]. Higher degree of specificity is required to predict pathology at an initial stage. Ensemble methods were utilized for improved efficacy of the weak classifier. Accuracy level is increased up to 70% by using these methods. IoMT provide therapeutic facilities to people suffering from any orthopedic disorder, relevant bones, muscles and joints especially in current context of COVID-19 [2]. IoMT deliver solutions to all such issues and offers management by ML approaches even in remote areas, thus decreasing patient's stress level as well as increased satisfaction of medical staff. Unnecessary hospital visits have also been reduced by uninterrupted association between a doctor and patient [16].

While implementing corona precautionary measure, population is constantly facing issues regarding availability of treatment facilities. For routine checkup regular contact with physician is required. The mobility of patients are severely limited due to their preceding surgeries, replacement of joints and fractures. Due to COVID-19, their nonstop communication with the doctor is not possible. Moreover, pain in orthopedic diseases occasionally comes out to be intolerable (Fig.4), therefore, development of modern cloud-based technologies is the requisite [2]. The working involves integration of healthcare machines, medicinal therapeutic system, durable internet connectivity and allied facilities. The arrangement is in charge for data collection, report analysis,

inspection of database, and additional exploration (Fig.5). Most efficient services are provided to orthopedic patients. Most operational management with innovative and advanced IoMT technologies is attained. Artificial intelligence (AI) based digital monitoring systems with data analysis tools, smart disease monitoring and scanning devices facilitates the fight against COVID-19 with faster detection approaches. Drug and vaccine development is also dependent upon AI, thereby, lessoning the burden of work faced by healthcare sector [17]. Internet of medical things assisted the health care personals surgeons for effective organization of their work in hospitals. IoMT might be a tool in hospital management as [18].

Recognition of relevant issues

- Organization of patients' influx and efflux
- Assessment of staff activity and productivity

The internet of medical things is excessively used in the area of medicinal domains, along with wireless sensors, multiple machines, means of transportation and different kinds of robots. These help by continuous surveillance of patient's health as a substitute of hospital admission, thereby increasing movement of patients. Likewise, robots are involved in various medical procedures for surgical purposes, efficiently and accurately, Robots are capable of performing CPR (Cardio-pulmonary resuscitation [19, 20].

6. Challenges

The major challenge encountered by physicians while using IoMT is to shield of patient's confidentiality, without violation of security level. The foremost issue is the vulnerability of IoMT to cyber-attacks owing to fragile safety background or maybe not secured completely. Consequently, these extreme effects can threaten the lives of some patients [4].

Currently, IoMT is facing the following challenges:

- Lack of No integration among IoMT components
- Confidentiality and safety concerns - Data hacking
- Unauthorized use of IoT
- Errors in data processing and integration
- Interoperability

Hacking of data creates confidentiality issues as it collects sensitive personal information about patients. It is an upsetting condition for patients because an unknown outsider will have access to patient data. Confidentiality warrants the prerequisite for secrecy, non-likability and limited observability. The characteristics of a person must be reserved, in other words, it can be assumed that submissive attacks might have the knowledge about work but persist uninformed of that personality. Patients are more doubtful regarding the machines use as compared to the physicians and nurses [21].

Many people lost their lives due to inadequate working of the medical machines, more than thousand people got injuries and about eight thousand cases of malfunctioning were reported between the years 2000 to 2013 due to incorrect judgment of many patients and wrong prescription given by the doctor [22]. IoMT achievement is that it increased surveillance of far-flung areas for the provision of medical services. It detects health care issues at very early stages and supports in saving patient's life. Though, it is very crucial to resolve the security concerns for better functionality and precision of the IoMT. Failing to do so, it may disturb the IoMT system [23].

Table 1: Benefits of IoMT

More accuracy	Real time tracing	Secure personalized treatment
Large data sets	Virtual visits	Remote sensing
Better protocol compliance	Cost reduction	Continuous care
Connect stakeholders	Therapy adherence	Faster registration
Adjustable as per user's requirement	Identification of new disease characteristics	Fewer trials required

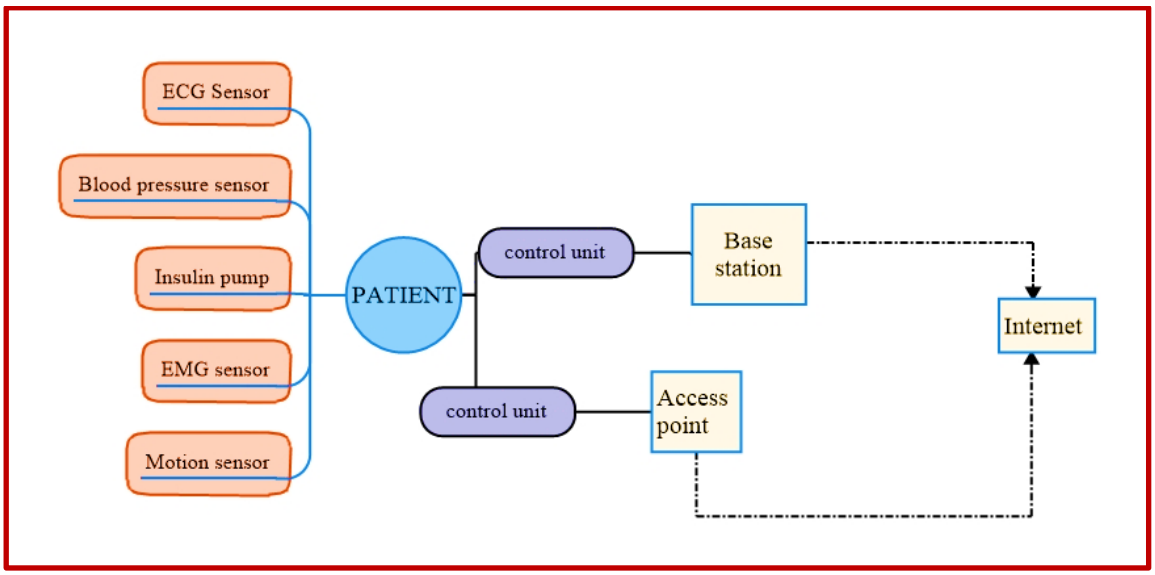

Fig. 1: Process Flow Diagram - Body Area Network

ECG: electrocardiogram, EMG: electromyography

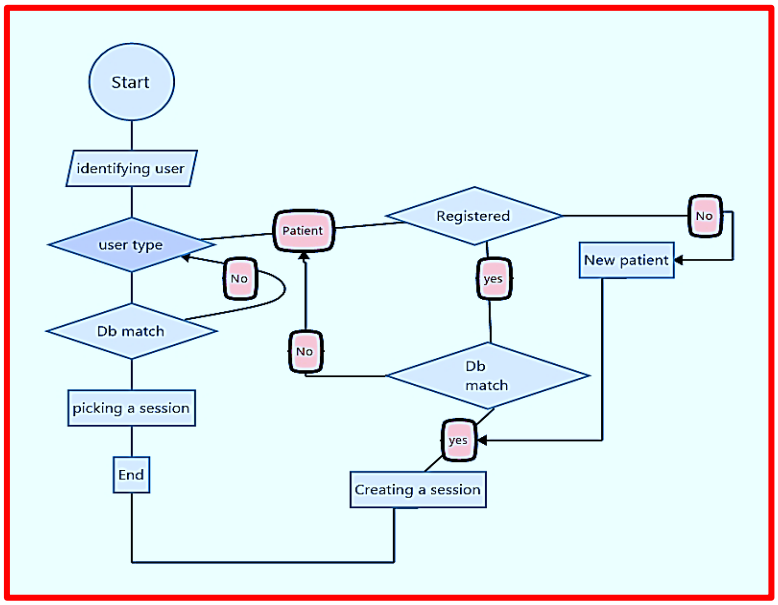

Fig. 2: Flow chart representing a Telemedicine network

Db: data base

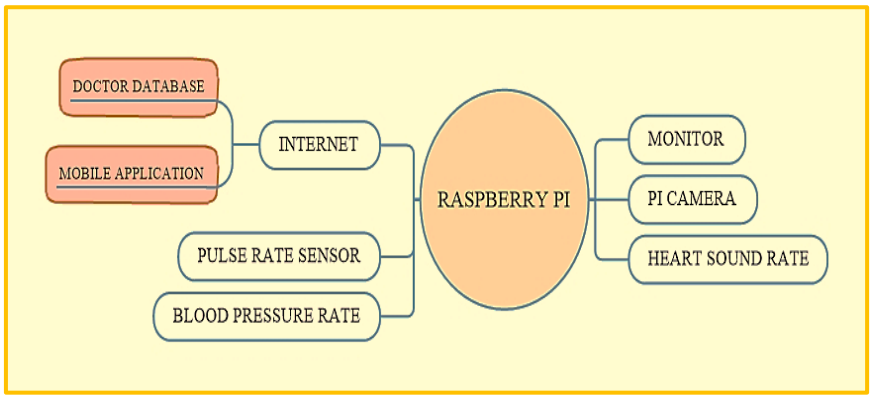

Fig. 3: An IoT Architecture for heart diseases

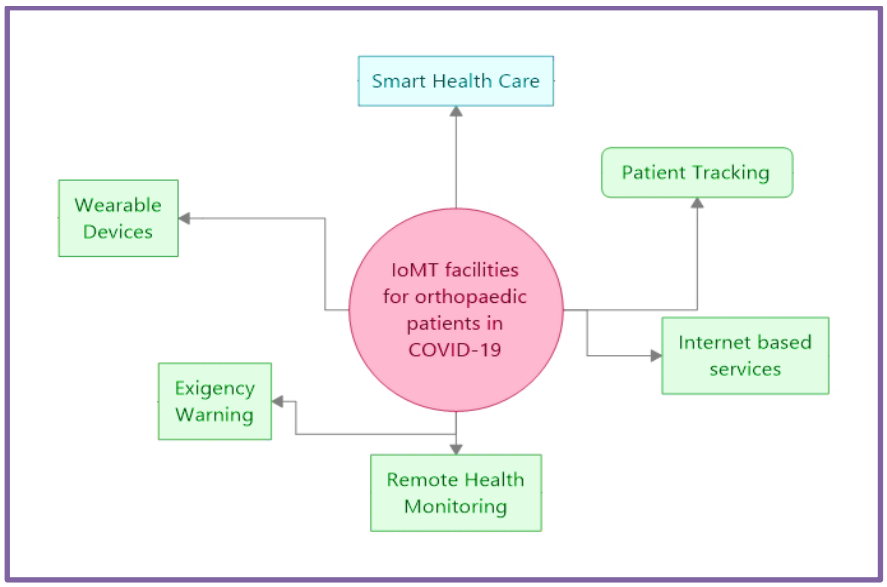

Fig. 4: Demonstration of IoMT services during COVID-19

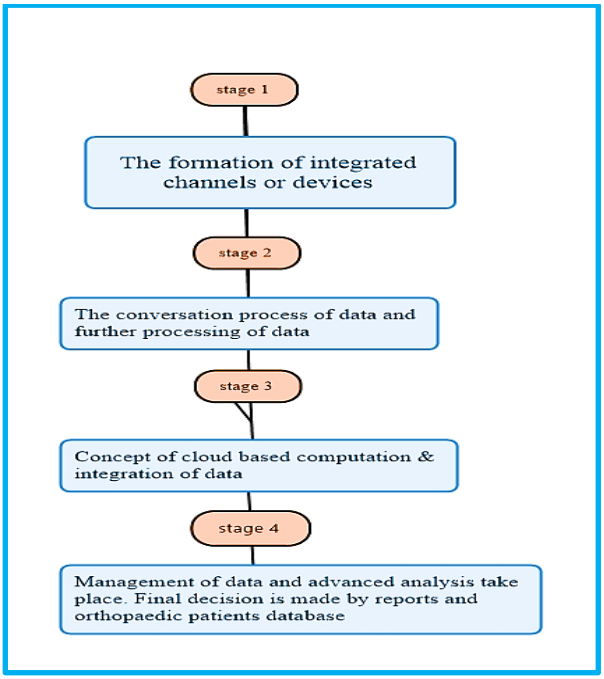

Fig. 5: Flowchart of methods used in IoMT technology

4. Conclusion

During the current scenario of COVID-19 pandemic, there is a need for broad adoption of Internet of Medical Things (IoMT). By the implementation of telemedicine and IoMT, physicians can diagnose and detect the diseases more effectively while maintaining the social distance. The burden on health care systems could be lowered down by the use of IoMT. Multiple kinds of algorithms are used for the detection of problems. With countless applications and benefits, telemedicine and IoMT have some limitations too that need to be addressed. Healthcare stakeholders should focus on improving the security system for better diagnosis and treatment of diseases while keeping secure the confidential information of patients.

References

[1] B. Lin and S. Wu. (2020). COVID-19 (Coronavirus Disease 2019): Opportunities and challenges for digital health and the internet of medical things in China. OMICS: A Journal of Integrative Biology. 24(5): 231–232.

[2] R.P. Singh., M. Javaid., A. Haleem., R. Vaishya and S. Al. (2020). Internet of medical things (IoMT) for orthopaedic in COVID-19 pandemic: Roles,

challenges and applications. Journal of Clinical Orthopaedics and Trauma. 11(4): 713-717.

[3] H.L. Truong and S. Dustdar. (2015). Principles for engineering IoT cloud systems. IEEE Cloud Computer. 2(2): 68–76.

[4] J.P.A. Yaacoub., M. Noura., H.N. Noura., O. Salman., E. Yaacoub., R. Couturier and A. Chehab. (2020). Securing internet of medical things systems: limitations, issues and recommendations. Future Generation Computer Systems. 105: 581-606.

[5] O. Kocabas., T. Soyata and M.K. Aktas. (2016). Emerging security mechanisms for medical cyber physical systems. IEEE/ACM Transactions on Computational Biology and Bioinformatics. 13(3): 401–416.

[6] V. Chandrasekhar., J.G. Andrews and A. Gatherer. (2008). Femtocell networks: A survey. IEEE Communications Magazine. 46(9): 59–67.

[7] M.M. Abdellatif and W. Mohamed. (2020). Telemedicine: An IoT based remote health care system. International journal of online and biomedical engineering. 16(6): 72-81.

[8] P. Chanda., K. Mukherjee., S. Modak and A. Nath. (2016). Gesture controlled robot using arduino and android. International Journal of Advanced Research in Computer Science and Software Engineering. 6: 227–234.

[9] S. Bharati., P. Podder., M.R.H. Mondal and P.K. Paul. (2021). Applications and challenges of cloud integrated IoMT. In Cognitive Internet of Medical Things for Smart Healthcare. Studies in system, decision and control. 67-85.

[10] K. Divya., A. Sirohi., S. Pande and R. Malik. (2020). An IoMT assisted heart disease diagnostic system using machine learning techniques. In Cognitive Internet of Medical Things for Smart Healthcare. Studies in system, decision and control. 145-161.

[11] P.M. Kumar and U.D. Gandhi. (2018). A novel three-tier internet of things architecture with machine learning algorithm for early detection of heart diseases. Computers and Electrical Engineering. 65: 222–235.

[12] R. Shashikant and P. Chetankumar. (2020). Predictive model of cardiac arrest in smokers using machine learning technique based on heart rate variability parameter. Applied Computing and Informatics.

[13] S. Mezzatesta., C. Torino., P. De Meo., G. Fiumara and A. Vilasi. (2019). A machine learning-based approach for predicting the outbreak of cardiovascular diseases in patients on dialysis. Computer Methods and Programs in Biomedicine. 177: 9-15.

[14] J.J. Beunza., E. Puertas., E. García-Ovejero., G. Villalba., E. Condes., G. Koleva., C. Hurtado and M.F. Landecho. (2019). Comparison of machine learning algorithms for clinical event prediction (risk of coronary heart disease). Journal of Biomedical Informatics. 97: 103257.

[15] C.B.C. Latha and S.C. Jeeva. (2019). Improving the accuracy of prediction of heart disease risk based on ensemble classification techniques. Informatics Medicine Unlocked. 16: 100203.

[16] F. Qureshi and S. Krishnan. (2018). Wearable hardware design for the internet of medical things (IoMT). Sensors. 18(11): 3812.

[17] R. Vaishya., M. Javaid, I.H. Khan and A. Haleem. (2020). Artificial Intelligence (AI) applications for COVID-19 pandemic. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 14(4): 337–339.

[18] R. Suman., M. Javaid., A. Haleem., R. Vaishya., S. Bahl and D. Nandan. (2020). Sustainability of coronavirus on different surfaces. Journal of Clinical and Experimental Hepatology. 10(4): 386-390.

[19] J. Rosen and B. Hannaford. (2006). Doc at a distance. IEEE Spectroscopy. 43(10): 34–39.

[20] R.A. Beasley. (2012). Medical robots: Current systems and research directions. Journal of Robotics. Article ID: 401613.

[21] P.H. Kahn., T. Kanda., H. Ishiguro., B.T. Gill., J.H. Ruckert., S. Shen., H.E. Gary., A.L. Reichert and N.G. Freier. (2012). Do people hold a humanoid robot morally accountable for the harm it causes? Proc Seventh Annuual ACM/IEEE International Conference on Human-Robot and Interaction. 10: 33–40.

[22] J.D. Birkmeyer., T.A. Stukel., A.E. Siewers., P.P. Goodney., D.E. Wennberg and F.L. Lucas. (2003). Surgeon volume and operative mortality in the United States. The New England Journal of Medicine. 349: 2117–2127.

[23] J. Sensmeier. (2017). Harnessing the power of artificial intelligence. Nursing Management. 48(11): 14–19.