

Iot with Dentistry: Promising Digitalization of Diagnosis in Dental-Health to Enhance Technical Dexterity



Babita Kaushal, Arvind K. Sharma, Avinash Sharma

Abstract – Health is more crucial area of sustainable inventions/ developments in many countries as well as the Information-Technology. Due to continue technical advancement, IT gonna very much involved in Dental/ Medical/ Paramedical Sciences for better prediction or analysis concern to various diseases. IoT is a domain which spread its feet in these areas from last decade onwards, as a result of which not only medical-personalities even laymen’s taking the benefits to track their diseases on daily basis by using new generation gadgets like Smart-Phone, Smart-Watch etc. With such technical advancements Dentistry completely transformed to computerized system (i.e. IoDT) which improved diagnostic techniques for management/ prevention of Dental-Caries, Periodical-Diseases, Oral-Cancers etc. Nowadays ‘Internet-of-Dental-Things’ even though successfully playing significant role in data collection, analysis (mining) w.r.t. data, monitoring the statuses of patients for oral healthcare but not limited to these only, i.e. also spread hands to contrive research activities in that particular area. In this paper we’re focusing especially on IoDT, its applications, challenges, new conceptions in dental sciences etc.

Keywords: – Data Mining, Dental Sciences, Interconnectivity, Internet of Things (IoT), Internet of Dental Things (IoDT), Internet of Medical Things (IoMT), Oral Health Care, Tele-Communications, Warehouse, and Wireless-Sensor

I. INTRODUCTION

Internet of Things (IoT) is a significant enhancement in technology (i.e. a mixture of variety of thing like: Artificial Intelligence/ Cloud-Computing/ Data-Science/ Internetworking and Security etc.) which gaining ground in telecommunication rapidly to provide services. Undoubtedly fundamental strength behind IoT is its huge impact towards various aspects of daily-life as well as potential user behavior [1]. We can be able to segregate effect/demand of IoT with various parameter (such as by Type of Users: Private/Commercial); As per Private-Users demand of IoT is most obviously visible in ‘Assisted-Living’, ‘E-Health’, ‘E-Learning’ etc. similarly on the side

Commercial/Business-Users effect is crystal clear in the area of ‘Automation’, ‘Business-Process-Management’, ‘Industrial-Manufacturing’, ‘Astute Transportation of People/Goods’ etc.

Apart from this in point of an interaction of ‘Computing-Tools’ along with ‘Machine-Driven’ appliances leading to the digitalization of information so that a network could be formed for transferring data without being dependent on person’s interaction with each other. It has invaded every field of the industry including especially ‘Health-Care’ on an unprecedented scale.

In healthcare system the **Internet of Medical Things (IoMT)**, is an implication of the IoT for medical and health related processes (i.e. collection of Data, Research-Analysis and absolute Monitoring). That mean IoMT has been addressed as ‘**Smart-Healthcare**’ due to inclusion of technology & it’s on going advancements for advertising a digitised system with available resources of ‘**Medical-Sciences**’. It’s becoming the indispensable aspect of diagnosis and treatments in healthcare which exact means, it has revolutionised the medical domain in terms of advancements from the quintessential way of treatment mechanics which has not only benefitted the patients but also curtail the hazards of a physician. The benefits of IoT in the medical becoming multidimensional like: Monitoring-Health (with Smart-Bands), Notification towards Emergency Systems etc. These health checking devices can range from ‘Blood-Pressure’ and ‘Heartbeat Rate’ assessment to advanced equipment’s capable to monitor specialized implants like ‘Pacemakers’. Along with medical field, IoT has spread its feet in Dentistry as well and, provided foundation to **Internet of Dental Things (IoDT)**. There are multifarious applications of IoT in dental field which has revolutionised the diagnosis and treatment mechanics to a great extent. IoT has changed the face of ideology and well as biomechanical treatment aspects of medical field.

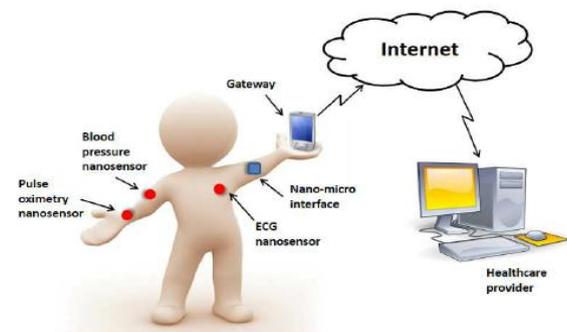


Fig 1.1: Internet of Medical Things

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IoT devices are dependable as well as powerful therefore, collection and transferring of health data including ‘Blood-Sugar’ levels ‘Blood-Pressure’, ‘ECGs’, ‘Heart-Beat’ and ‘Weight’ to monitor irrespective of their location and time-range become easy and quick. Apart from above certain medical emergencies can be prevented by continuous monitoring by utilizing smart technology and make capable laymen’s to self-check i.e. for vital signs. Smart gadget [10] changed the way to spot sickness and to fast diagnosis, treatments. Consequently, such system has brought down the cost, by declining avoidable visits.



Fig 1.2: Smart Gadget

The rest of the paper is organized as Section II describes Applications & IoT in Dentistry, Section III about IoT Security & Aegis in Healthcare, Section IV Comparative Analysis of Sensors Used in Dental Science and, Section V our Proposed Work after that suitable Conclusion provided.

II. VARIOUS APPLICATIONS & IoT INVOLVEMENT IN: DENTISTRY

Internet of Things is becoming the integral part of dentistry having numerous conceptions behind to owe it; actually dentists are seeking for advanced technologies in order to provide accurate diagnosis and effective treatments. IoT along with IoMT leads to formation of ‘IoT Cloud’ [1] [5] having significance in dentistry.

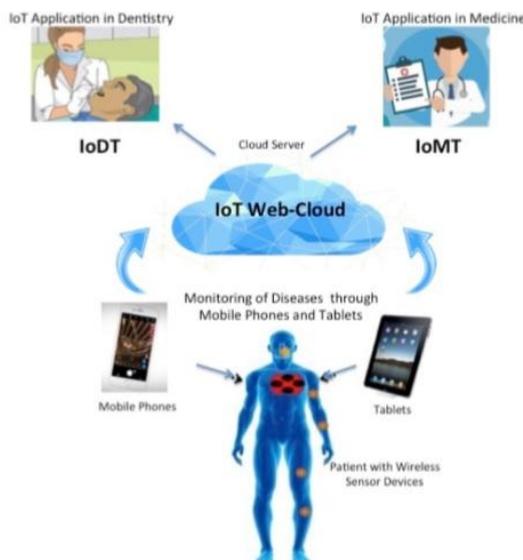


Fig 2.1: IoT Web-Cloud [5]

Till date, there is plethora of digital technologies which has become the integral part of dentistry. It has replaced the traditional methods because they are more reliable and accurate. Below some area where technology used in Dental-Sciences with IoT inclusion/ Possible-inclusion we’re discussing.

2.1) 3-D Printing

Surgical guide planes are the tools responsible for flawless surgical implants installation and 3-D printing is utilized to manufacture it. Secondly, it is also used for manufacturing of aligners, night-guards and even crowns.

2.2) CAD-CAM

CAD/CAM is a latent computer based technology for the dental prosthesis fabrication. The significant functions carried out via this technology is digital-scanning by software followed by fabrication of the appliance is done in this technique.

2.3) Cone-Beam Computed Tomography

Cone-Beam Computed Tomography (CBCT) is the latest technique that generates 3-D images at a lower less radiation. Today, three-dimensional imaging is providing dentists with unimaginable diagnostic and therapeutic options in the fields of surgery, prosthetics, orthodontics, and restorative dentistry.



Fig 2.2: CBCT

2.4) Digital Impressions

A proper impression forms the pavement of excellent treatment outcomes. Digital impressions have evaded out the errors caused by shortcomings in impression taking. By Using ‘Lasers’ and, ‘Optical-Scanners’, Digital Impressions offer virtual and exact replica tissues of the mouth.

2.5) Digital-Radiovisography

The recent X-ray technology brought in dentistry is RVG i.e. Digital-Radiovisography. The machine is equipped with Special Software that analyze image. Here the image can be saved in enlarged form.

2.6) Digital X-Rays

To better diagnose the oral lesions and conditions, dental professionals shows a proclivity towards using digital radiographs that uses digital X-ray sensors to surpass the traditional films.

2.7) Electronic Apex Locator

This electronic device which has eased the root canal treatment by digitalization and have completely eradicated the flaws associated with manual endodontic treatment.

It accurately measures the resistance and impedance of the surroundings to determine apical constriction.



Fig 2.3: Electronic Apex-Locator

2.8) Electronic Dental Records

In many dental clinics, for patient’s clinical-data and information the most effective and efficient way of storing data is in electronic form using the appropriate software as it saves precious time of practitioner and also easy on the pocket. Recent study shows that, around 70-75% dental practitioners in USA and 90-95% practitioners in Scandinavian Countries used ‘EDR’ to store clinical-data in their dental offices [5]. These numbers are increasing constantly day by day, because more and more dentists are storing most of their data electronically today; because EDR is easy, cost effective, and timesaving method; additionally the clinical data is used subsequently in dental research purpose.

2.9) Orthopantomogram

An Orthopantomogram (OPG), which is also known as an ‘orthopantogram’ or ‘panorex’, is a panoramic scanning dental X-ray of the jaws which is of immense importance to detect periodicals lesions of teeth of maxilla and mandible.

2.10) Smart Toothbrush

The Smart-Brush is one of the finest toothbrush having sensors in its head that send information, via ‘Bluetooth’ to an ‘Interactive-App’ on ‘Smartphone’. It records frequency, pressure and angle of toothbrush while brushing. It is of extreme importance in pedodontics to have a track of brushing habits of children/ adults.



Fig 2.4: Smart Tooth Brush

2.11) Smart Mouth Guard

This device is a boon to people under stress diagnosed by grinding of teeth. Due to the sensors embedded in mouth-guard which detects the vibrations caused by grinding, they are being warned by alarms send via ‘Bluetooth’ to their ‘Smartphones’.



Fig 2.4: Smart Mouth-Guard

2.12) Virtual Reality

Virtual Reality is an advanced computer-generated technology, in which the surrounding is imitated in 3-dimensional replica, giving the patient experience as if he/she is at the center of that environment and can interact personally by using special electronic devices. This simulation advances are used in different aspects of medical fields like treatment of anxiety patients in neuropsychology, pain and angst management, surgical training in neurology as well as medical student education. There is a rapid research going on VR application in dentistry for surgical training and dental student education in preclinical lab.

2.13) Augmented Reality

It is illustration of information to allow data visualization of measures of diagnostic value. It is effective during implant placing in orthognathic surgeries. Recently it is being used in dental field of orthodontia, endodontia and restorative dentistry.

III. SECURITY & AEGIS OF IoT IN: HEALTHCARE

Security: Security is major concern always when we talk about ‘Data’ or ‘Services’ provided by some specific systems (i.e. for Data Collection/ Preservation/ Analysis/ further Automatic-Decisions (i.e. with ML/AI), level of access to that data w.r.t. authority of resource) to performs significant operations, in industry like ‘Banking’ , ‘Education’, ‘Health-Care’, ‘Defense’ etc. Though due to advancement in technology various fruitful schemes [9] [11] [12] [14], methodologies, devices available to provide protection as well as to maintain the privacy yet, lots of loop-holes/back-doors be there too for applying attacks [10] [13] by bad guys (like: Malicious Hackers, as they’re spent their time in searching of these back-doors). Now when we consider IoT devices; these capture and transmit data in real-time. However, most of the IoT devices lack Data, Protocols and Standards. In addition to that, there is significant ambiguity regarding data ownership regulation. All these factors make the data highly susceptible to cybercriminals who can hack into the system and compromise Personal Health Information (PHI) of both patients as well as doctors. Adversaries can misuse patient’s data to create fake IDs to buy drugs, medical equipment which they can sell later fraudulent insurance claim in patient’s name.

Data Overloading: As already discussed, data aggregation is quite tedious due to usage of distinct communication protocol(s) & various standard(s). But still devices concern to IoT record a tons of data. i.e. IoT devices that captured such data are further utilized to gain vital insights. The main issue here is the collection of data, which is so tremendous that deriving insights from it becomes quite hectic job for doctors which influence the quality of decision-making too. Moreover, this concern is rising as more devices are connected which record more and more data.

Cost: Well surprisingly have a look on cost in the challenge sections? IoT hasn't fixed the healthcare facilities affordable to the common man yet but it'll be in near future. The boom in the **Healthcare costs is a worrying signs obviously for everyone especially in developed countries. The situation is such that it gave rise to 'MEDICAL-TOURISM' in which patients with critical conditions access healthcare facilities of the developing nations which costs them as less as 1/10.** The notion of IoT in healthcare is a fascinating and promising. However, as per the study it hasn't solved/ reduces the cost as of now. To successfully implement IoT app development and to gain its total optimization the stakeholders must make it cost effective otherwise it will always remain out of everyone's reach except the people from the elite class.

IV. COMPARATIVE ANALYSIS OF: DENTISTRY SENSORS

When we discuss about Internet-of-Things, a very important component on which much of activities depends is a 'Sensor'. Through sensors information of various types

communicated towards destined locations with other intermediary interconnected devices for further analysis/ decision making. (E.g. alert (message) about air-conditioned is running at home directly conveyed to owner if no one in home and many more on phone; it's possible with IoT but who's initiating the process the answer is: Sensor). Similarly in Dentistry/ Medical-Sciences sensors are playing vital role from years, but specifically in Dentistry we've very less sensors available as compare to Medical-Science, which're available much among those're not parallel working with IoDT/ IoT i.e. we're lacking somewhere in this area even though IoT with branches growing day-by-day. Previously dentist's only depends on X-Ray and not in favor of Digital-Images, But CCD/ CMOS developers took the initiative for change [16] [17]. In current market CMOS based sensor widely used in Dental Sciences as compare to CCD. So before writing bit about our proposed work in this article we're providing suitable analysis of available dentistry sensors, with suitable description what we can do in IoDT with these sensors in this direction for betterment of dentistry. Suitable analysis is as under below:

Table 4.1: Comparative Analysis of Dentistry:Radiography Sensors

PARAMETERS		TECHNOLOGY USED	POWER CONSUMPTION LEVEL	IMAGE QUALITY LEVEL	PIXEL SIZE	DATA TRANSFER RATE	COST
SENSOR	PURPOSE						
CDR-APS	Intraoral Digital Radiography	CMOS	LOW	HIGH	48µm	HIGH	LESS
DIGORA					70µm		
DEN OPTIX		PSP	HIGH	MODERATE	42µm	LOW	MUCH
RVG					39µm		
RVG-S					18.5µm		
SENSE-A-RAY		CCD	VERY HIGH	LOW	45µm	LOW	MUCH
VIXA/ VISUALIX					63µm		
FLASH DENT					39µm		

V. PROPOSED WORK: IoT BASED DENTISTRY SENSOR

From dentistry background it's very much clear that technology spread its feet around three decade ago in this area i.e. digitalization, that made dentist's work much smoother than past. But now world is moving with new technology in interconnected environment with combination of Artificial Intelligence, Big Data, Machine Learning, Data Warehouses etc. (i.e. IoT in one word) to provide well versed services in every area with the help of Engineering/ IT discipline. Still there're many areas which untouched from this advancement specifically in Healthcare like Dental-Science or Dentistry. So in our proposed work we're going to develop something new/ innovative Sensors (as very few sensors available, not smart) particularly for measuring 'Calories-Intake' which will disclose to Normal Person as well as to Patient with the help of Smart-Device: "Is the diet which he going to take contain Carbohydrate, Fat, Protein etc." if Yes "at how much in %", so that "Diet can be controlled in case of Normal Person" or "immediate decision Patient will be able to take under the supervision of medical-specialist" (whether from Dental/ Medical) w.r.t. disease he's suffering from as well as automatic records will reached to medical-specialist daily/ weekly for further analysis and no need of patient presence there every time

when requirement arises, which not only reduce the cost of both sides but also save the time too, In our next article we'll provide thorough detail with full implementation of that particular device with its benefits by taking the help of suitable facts, as this article is only dedicated to study work in this direction.

VI. CONCLUSION

From the comprehensive study work, we can say that IoT has significant impact in Healthcare to provide demanded services from past one decade, yet influence is less in Dentistry but will be involved/ continuously involving in this particular area. There is many department(s) where even IoT/ Technology still untouched the dental science and dentist following traditional methodologies to perform diagnosis, analysis etc. with poor quality or too much delay with increasing cost. But it's crystal clear from IoT background that many areas like Banking, Defense, E-commerce, Transportation etc. capturing benefits, so if some more innovation will occur in Healthcare specifically in Dentistry apart from Other Medical Areas then more services provides to patients with ease, accuracy and on-time. With respect to our proposed work we're focusing on particular type of new sensor for dentistry with various characteristics as mentioned before for betterment of further processes.



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