International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 6, September-October 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

An Analysis on IoT Methodologies for Smart Health Care and Surgical Treatment using Haptics

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ABSTRACT

The emerging technologies that make up Smart health care and surgical treatment, involve the Internet of Things. The haptic interfaces were used in various industries, but obviously, they are not incorporated with the two tools discussed above. This study seeks to know what the present usage of IoT has been incorporated into haptic interfaces in the smart health care and surgical treatment. This article describes the necessity for haptics (feeling of touch) in medical modeling systems and explains a wide range of laparoscopic training systems and other surgical simulators.

KEYWORDS: *IoT, haptic interfaces, IoT architecture, smart health care and surgical treatment*

How to cite this paper: B. R. Kavitha | P. T. Jamuna Devi "An Analysis on IoT Methodologies for Smart Health Care and Surgical Treatment using Haptics" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-6, October 2020, pp.115-120, URL: www.ijtsrd.com/papers/ijtsrd33135.pdf

IJTSRD33135

1. INTRODUCTION

The sense of touch is something natural for the people. It makes it easier for us to describe size, structure, mass and to familiarize ourselves in space, i.e. it gives the physical world around us the right dimension. In medicine it is essential for good clinical practice. Palpation, surgical interventions, phlebotomy and other interventional procedures are instances where the sense of touch is of significance. Clinical staff need to obtain experience and training in these procedures and acquire the 'feel' of the procedure before they can practice medicine safely. Since the early days of medicine this has traditionally been learn ton animals, cadavers or live patients. More recently mannequins and artificial tissue models have also been introduced, but in practice the way to learn medicine has remained unchanged for centuries.

Over the last 20–30 years new technology based oncomputer science and mechanics has made a major impact on training in many areas, including medicine, but very little of this has been routinely employed to improve medical training. Recent research and development in IoT and haptics (force feedback) is now making it possible to both see and feel virtual objects. This not only opens completely new possibilities for medical training, but also, in some areas, the practice of medicine. Haptics (pronounced HAP-tics) is the science of applying touch (tactile) sensation and control to contact with a computer. The development of the basic software and hardware for this has been described elsewhere. The technology as such is still in its infancy, but now commercial applications are rapidly emerging in a variety of fields. This review provides an overview of the main medical areas where a major impact is envisaged over the coming years.

2. Review of Literature

We utilized a combination of databases available at the online academic search engines and UACJ (Autonomous University of Ciudad Juárez), like the same UACJ search engine, Microsoft Academic, and Google Scholar. Appropriate articles have been searched in the databases EBSCOHOST, Emerald, ACM, IEEE Xplore, and Science Direct, among the most prominent. Google Scholar was the most important source to understand the measurements of offered literature. For this analysis of literature have been taken into account articles, conference reports and academic journals, that come up with a book chapter. The publication dates that were taken into consideration are within the range of 2015 to 2018, with a few considerations from previous literature to support concepts of the subjects examined. Though the researchers utilizea number of languages, the search was limited to articles in English. Most of the findings in academic explorations yielded articles published in the English.

3. Internet of Things (IoT) and Haptics

Internet of Things (IoT)-enabled devices have made isolated monitoring in the healthcare sector possible, exploiting the possibility to maintain patients healthy, and safe and encouraging the doctors to provide exceptional care. It has also improved patient involvement and customer fulfilment as connections with doctors have make it easier and more effective. Additionally, isolated surveillance of patient's health is helping to reduce the duration of stay in hospital and precludes re-admissions. IoT also has a significant effect on decreasing healthcare expenses considerably and enhancing treatment results.

IoT is definitely altering the healthcare industry through to redefine the space of machines and people collaboration in providing healthcare solutions. IoT has applications in healthcare that help patients, children, doctors, insurance firms and hospitals.

IoT and Haptics for Patients –

Machines in the type of portable devices like fitness bands and other wirelessly linked together machines such as blood-pressure and heart rate monitoring cuffs, glucometer etc. give patients access to customized attention. These devices may be tuned to recall the calorie count, exercise check, appointments, blood pressure variations and much more.

IoT has been transformed into individuals' lives, particularly the aged patients, by allowing the continual tracing of medical conditions. This has a significant effect on the people who live independently and their relatives. On any disruption or modifications in the routine events of a person, alert mechanism transmits signals to family members and anxious health providers.

IoT and Haptics for Doctors –

By utilizing handheld devices and other household surveillance equipment integrated with IoT, doctors can keep track of health of patients more efficiently. They will be able to track patients' compliance with the medication plans or any necessary for immediate medical care. IoT allows medical professionals to be much more watchful and link with the patients in a proactive manner. Data gathered from IoT devices can assist physicians determine the best possible treatment procedure for patients and achieve the anticipated results.

IoT and Haptics for Clinics –

In addition to the monitoring health of patients, there are many other areas in which the IoT devices are extremely useful in hospitals. IoT devices labeled with sensors are being used for monitoring the real time location of health equipment like wheelchairs, external defibrillator, oxygen pumps, nebulizers, and other surveillance equipment. Implementation of medical personnel at various locations can also be examined real time.

The disperse of infections is a significant concern for patients in hospitals. IoT devices also help in the management of resource like inventory control of pharmacy, as well as ecological monitoring, for instance, checking temperature in refrigerator, and moisture and temperature control. IoT-aided hygiene surveillance devices help to prevent patients from becoming infected.

IoT and Haptics for Medical Insurance Companies –

There are many opportunities for medical insurance companies with IoT-linked smart devices. Insurance firms can influence the acquired information through health surveillance devices for their financing and allegations processes. This information will allow them to recognize the scam claims and detect possibilities for financing. IoT devices bring clarity among insurers and clients in the financing, evaluating, claims management, and risk assessment procedures. In the light of IoT-seized data-driven determinations in all operation procedures, customers will have sufficient transparency into fundamental thought following every decision that was made and process results.

Insurers can provide enticements to their clients for utilizing and distributing health information produced by IoT devices. They can incentive clients for utilizing IoT devices to keep an eye on their routine events and ensuring compliance with the treatment plans and preventive health care measures. This will assist insurers to decrease the claims considerably. IoT devices can also allow insurance firms to confirm the assertions over the acquired information by such devices.

4. Redefining Healthcare

Rapid increase in the number of healthcare-specialized IoT and haptic products opens up enormous possibilities. And the massive amount of data produced by these attached devices hold the possibility to transform medical treatment.

IoT has a four-step architecture that are essentially the phases in a procedure (See Figure 1). All four phases are linked together in a manner that data is captured or handled at one phase and produces the value to the next phase. Integrated values in the process brings insights and provide dynamic business opportunities.

Step 1 : Initial phase is comprised of implementation of interrelated devices that comprises camera systems, detectors, monitors, actuators, sensors, etc. These machines gather the data.

Step 2 : Generally, incoming information from sensors and other appliances are in analog form, which will have to be grouped and transformed into the digital form for additional data handling.

Step 3 : When the data is digitalized and accumulated, this is pre-processed, regulated and transferred to the Cloud or data center.

Step 4 : The definitive data is administered and examined at the necessary level. Sophisticated Analysis, that apply to this data, brings effective business perceptions for efficient decision-making.

IoT is to be redefined healthcare by securing better care, enhanced treatment results and decreased expenses for patients, and improved procedures and work processes, better performance, and patient experience for healthcare providers.

Figure 1: The four stages of IoT solutions

The most important benefits of IoT and Haptic in healthcare include:

- **Cost-saving**: IoT allows patient surveillance in real time, thus dramatically cutting down excessive visits to doctors, hospital stays and re-admissions
- **Better Treatment:** It allows doctors to make evidence-based told decisions and makes complete transparency
- **Quicker Disease Diagnosis:** Uninterrupted patient surveillance and real time data facilitates in detecting diseases at an initial phase or even sooner than the disease improves based upon the symptoms
- **Proactive Treatment**: Constant health surveillance is opening the doors for offering proactive medical therapy
- **Management of Equipment and Drugs:** Administration of drugs and medical devices is a significant challenge in a healthcare sector. Through devices that are connected, these are administered and utilized efficiently with decreased expenses
- **Reduction of Error:** Data created through IoT devices not only assist in efficient making decision but also make certain efficient healthcare processes with diminished errors, waste, and system expenses

Healthcare IoT has not been without challenges. IoT-enabled connected devices are capturing vast quantities of data, involving confidential information, which give increase to concerns regarding protection of data.

Executing appropriate security arrangements is important. IoT is exploring modern aspects of caring for patients via real-time health surveillance and the ability to access health data of patients. This data is a success for healthcare stakeholders to enhance the health of patient and skills while making profit-making possibilities and enhancing health-care processes. Preparations are being made to exploit this digital power would turn out to be the distinguishing feature in the increasingly interconnected world.

Figure 2 Haptics in healthcare System

5. Haptics

The haptic term is linked to each other or is based upon the sense of touch; it could also be described by a tendency for the sense of touch, e.g. a haptic person. Vafadar also identifies haptics as the "feedback creation of touch and strength data." The study firm Gartner identifies haptic as the usage of physical interfaces to give touch response or force as a component of its user interface. This may be applied in the automobile industry to the user interface in vehicles to notify the driver of a pedestrian willing to cross the road by vibrating the seat. Haptic technological development has the possibility to introduce a modern method of interaction with the user, enhance serviceability and customer experience, and enhance information applications. In technological development, everything that is associated with haptic receives the term "haptics" or "haptics" in English.

Haptics can be examined in three key areas:

A. Human Haptics, which is proportionate to the touch detected by humans,
B. Computer-aided Haptics, which is the software that can be used for feeling and touching virtual objects, and
C. Haptic Machines, which suggests to the layout and usage of machinery that can enhance or restore a person's touch.

The haptic feedback channels can be tactile sensations, like temperature, texture, pressure, etc., can be touchy-feely vibro-stimulating Pacinian's corpuscles that identify vibrations of 40- 400 Hz, and Meissner's corpuscles that identify 5-50 Hz vibrations or kinetic perception, which identifies the condition of the body. Haptic devices can be categorized as per their interface: (i) Grasp or Take, (ii) incorporate, and (iii) touch. The incorporation of IoT with haptic interfaces is a subject in which few studies have studied the standards of tangible collaboration that can manage the conceptual design of interfaces for IoT which is situated in the real world.

6. Current Use of IoT and Haptic Interfaces in smart health care and surgical treatment

In the literature, the usage of IoT and haptic in smart health care and surgical treatment is commonly found, and it is very different. Smart health care system can be assessed, suggesting a model of experience of the intelligent health care system (authentication, surveillance, management, optimization and independence), where the integration of the usage of IoT and its information is improving. Also, hospitals that utilize IoT in their procedures do not communicating directly with the applications and devices. The applications satisfy three important functions: they allow the person to communicate with the IoT system through a graphical interface; offers the required abilities to imagine the data and offer a method for data analysis. For applications to satisfy such functions, they depend on IoT, its design and appliances, the storage of data of the haptic type, and the infrastructure to transport the data. Though, the analytics that can be calculated in haptic on the data collected from the company, can reach the order of 5,000 dimensions, revised by 200 billion personally identifiable information per day, useful for the planning and control of smart health care and surgical treatment operations, by example. That is why smart health care and surgical procedure must adopt haptic. The literature also details two kinds of consumption as well as data handling, in real time and batch-processing. Kho (2018) details an extremely limited number of references on the actual-time handling, which is described by the high requirement for infrastructure to allow this kind of handling. The qualities of haptic that permit to assess a huge volume of information to find patterns, their connections and developments, are referred to as analytics, and occasionally include the haptic concept. Haptic analytics are utilized effectively in smart health care and surgical treatment but fails to account many data analysis references in real time in IoT-assisted conditions. It also emphasizes the significance of data visualization happening in real time with tools like Tensor Flow. Health care system desiring to project into analytics and haptic have various challenges of knowledge before them: the maturity of the organization, the kinds of

IoT, the responsibility of haptic and its analytical models. For instance, if need to fulfill an IoT with haptic in a smart health care system, collections of billions of data are involved to be processed and greater than one forecast algorithm. The IoT and haptic combination can be seen beyond analytics in information obtained by sensors, like access security utilizing other developing tools.

7. IoT Architectures

Internet of Things (IoT) continues to develop from its concept. Several proposals have existed, adding complexity to solve the newly perceived challenges. In the health care system, it is a good practice to look at architectural references to prevent work and have a starting point to resolve the problem based upon the needs. In IoT there are five major needs in general:

A. Allow communication and the link among data handling and devices.
B. Create a method to handle devices, containing responsibilities like adding and eliminating devices, upgrading the software and settings.
C. Collect all the data generated by the devices and then examine them to offer a significant standpoint to the users or companies.
D. Enable scalability to cope with the enhanced flow of "data pipes" (which is mentioned as data pipelines) and the movement of information and manage an ever-increasing number of devices.
E. Protect the information by inserting the required tasks to offer confidentiality and trust among the users and the devices.

Numerous reference architectures with layers for IoT have been planned: one of the most important reference architectures is IoT-A. A layer is a theoretical grouping of elements to offer a specific feature and a readership or independent viewpoint. Weyrich and Ebert (2016) indicate three viewpoints of layers:

A. perspective oriented to monitor data link tasks and physical devices with low-level information transmission protocols.
B. Internet-oriented perspective, concentrates on interconnection and protocol conversation like MQTT or HTTP; and
C. semantic perspective with maintenance protocols for the usage and information sharing. As stated above, IoT has developed and is continually changing.

Architectures with various layers were planned, beginning in their easiest form with two layers. The Open IoT architecture is comprised of two layers, one for the semantic directory service and another for sensor middleware, but in the end, it could be categorized as a three-layer architecture, due to the need to have applications that consume data coming from the devices. Three-layer structural design are increasingly popular and recommended by various applications and various writers. They comprise of the device layer, the application layer and the communication layer.

An IoT architecture suggested for the application of organic tourism comprised of:

A. real world layer,
B. virtualization layer,
C. service layer and
D. application layer.

8. Potential Benefits for the Smart health care and surgical treatment by Implementing IoT with Haptic Interfaces

In the literature, the restricted information was discovered on the mixture of such problems in the smart health care and surgical treatment. The reported utilizes of haptic interfaces are particular and in activities except smart health care and surgical treatment, like in the health care industry, the liberal arts, and in the education sector. There are stimulating subjects from which one can attain suggestions for applications in smart health care and surgical treatment, like the time of hesitation among the action completed on the machine, the registration of this, and the action of the human, or the way to direct signals to the people in front of events noticed by IoT. One more is the usage of haptic interfaces in interactive museums, which could act as motivation for smart health care and surgical treatment processes. The haptic interfaces are now involving in wearables or garments, which consist of smart lenses. In the smart health care and surgical treatment processes, collaborative interactions were experimented, in which elements of IoT, haptic interfaces and RFID have been incorporated into a simulated environment. This virtual reality can have a direct effect on cost reduction and productivity. They can also be implemented in prototype models, reducing the expense of creating these as they are essential products. An Additional area with possible advantages for smart health care and surgical treatment is the combination of ergonomic design with orthostatic sensors in chairs. This incorporation of equipment technology may have advantages in additional fields, involving organizational ones, for instance to decrease the expense of watch clocks once detecting the user. In smart health care and surgical treatment, the usage of IoT has brought advantages like the resolution of complicated assembly proposals for airplane engines, or also in the method of printing and a gathering of packaging information. The usage of IoT and haptics opens the door to physical communication with computers that have the ability to reduce the learning curve of utilizing a tool or system in comparison to the computer-man interfaces. An instance of this advantage is in the treatment at home through devices that facilitates the patient to carry out the exercises prescribed by their doctor, without having a keyboard or a screen. This could be applied to a smart health care and surgical treatment procedure that will be conducted remotely, reducing the threat to the user or reducing travel expenditures of a specialist. Currently, such processes where IoT intervenes are crucial in the data gathering that is stored in haptic, originating from the natural environmental data, people as well as computers and artificial intelligence applications. This massive amount of information are applicants to be examined by haptic, applying unsupervised or supervised prediction procedures, or modeling. Albuhamood, in his doctoral dissertation, makes reference to the usage of genetic algorithms to schedule subtasks to optimize the system. Also, the combination of IoT with haptic has created very great expectations that must be taken very seriously by the number of billions of devices that will be connected. The specific potential advantages of combining IoT and haptic are described or planned in various activities as successful examples. The usages are as wide-ranging as the discovery of diseases in plants, fruits a crop, the projection of air quality, or in the medical sciences, to assist with Parkinson's disease, Alzheimer's or additional related problems. In the field of smart health care and surgical

treatment, the usage of a conveyor line with the capability to identify kinds of automated slats was discovered thanks to haptic. The other aspect where there is a very narrow use between IoT and haptic is in the safety and security that must continue in IoT and how to identify the intruders and attacks to the machines through smart projections. The research of the cyberspace in IoT is as essential as its utilizes and applications for the company and justifies a separate examination.

9. Clinical Practice

The application of haptics to clinical practice is still in the early phases of advancement but much research and technological development is progressing. Since this will be directly involve a patient the relevant authorities have imposed much stronger regulations in this area, especially in relation to robotic surgery. This will most probably slow down the introduction into routine use. The other two areas, surgical planning, and diagnostics might grow faster because of fewer regulatory constraints.

10. Diagnostics

Computer-generated images of the body, other than traditional x-rays, have today become standard. Figure 3 Screen shots from a training session on neck anatomy. The student can learn the different parts of the neck anatomy by touching them and obtain the names, sensation of touch and 3-D alignment by carrying the probe on the robot arm.

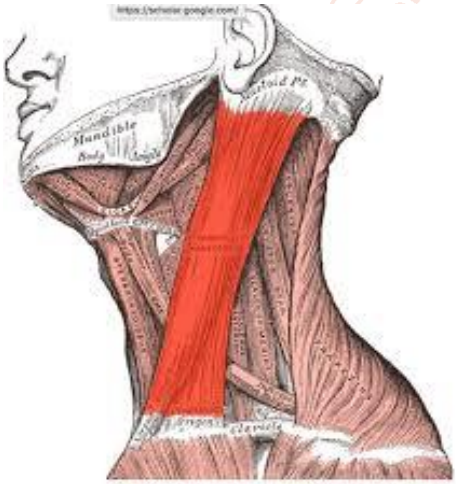

Figure 3 Training Section of Anatomy of Neck

11. Usage of haptics in medical applications

Resonance Imaging) PET (Positron Emitted Tomography), and Ultrasound etc. This has made it possible to identify structures not visible on traditional x- rays. They also make it possible to provide a 3-D representation of the body. Interpretation of these images is a skill, which requires training, time and a skilled eye. Automatic segmentation of organs and structures is on its way [18], but personal interaction with the images is still needed in today's clinical practice.

In the medical field continued research is making virtual endoscopy possible. This means that invasive diagnostic procedures like e.g. gastroscopy and colonoscopy may be rendered non-invasive. With haptic feedback the borders between organs can be felt and travel inside structures is made possible. This can significantly help in interpreting data from virtual endoscopies. Tumor diagnostics is also an area of interest for this technology. In principle this can be performed in a 3-D environment without haptics. However, experience from the oil and gas industries, with applications for editing 3-D rendered seismic data of earth layers and planning drill paths, shows that adding the sense of touch to the exploration may provide a more intuitive way of working that will speed up the processes.

12. Surgery and treatment planning

The resulting data from diagnostic procedures can also be utilized for treatment planning. In surgery it may be useful to see what the organs look like before the actual surgery is performed, since this may prevent technical complications. During reconstructive surgery it is crucial to make a model of the new appearance and plan where to make the incisions and redistribute the tissues. Presently real models are built from images, but with the new technology testing and modeling in 3-D with haptics, multiple reconfigurations can be undertaken, and thus more options can be tested faster and at a much lower cost. For the purpose of reconstructive surgery it is in theory possible to take the 3-D image of the patient, modulate it in the IoT-haptic environment and use the result to show the patient, and then have it as an overlay when the surgery is performed. This is very easy to apply to maxillo-facial reconstruction and has been described in more details as part of recent exam theses. As a part of the theses even a demonstration application has been developed utilizing patient CT-data.

Applications, based on the Reachin API, have also been developed in the area of radiation treatment of tumors and as an interface to plan the dosage and help in directing the radiation beam. One of the applications is currently being further developed and will soon undergo a validation of usability.

13. Summary

The use of IoT with haptics in medical applications is still in its infancy. However, there is a broad variety of applications where this may speed up procedures and make them more efficient, cheaper and add to patient safety. Products for medical training in surgery and other procedure simulators are already on the market, but areas like medical image interpretation for diagnostics and surgery and treatment planning will benefit greatly from the technology in the future. The use of the Internet will also play an important future role. All movements can be sent electronically over the web and be felt interactively by distant colleagues. This will make robotic surgery easier, safer and render remote apprenticeship possible.

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