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RESEARCH ARTICLE

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Flexible and Wearable Antennas: Enabling Smart Healthcare Systems

Prakhar Goyal[1*], Shashikant Patil[2], Poonguzhali S[3], Sidhartha Dash[4], Ezhilarasan Ganesan[5], Varsha Choudhary[6], Ansh Kataria[7]

[1]Quantum University Research Center, Quantum University, Roorkee, Uttarakhand, 247667, India.

[2]Professor, uGDX, ATLAS SkillTech University, Mumbai, India,

[3]Assistant Professor, Department of Electronics and Communication Engineering, Sathyabama Institute of Science and Technology, Chennai, India,

[4]Associate Professor, Centre for Internet of Things, Siksha 'O' Anusandhan (Deemed to be University), Bhubaneswar, Odisha, India

[5]Professor, Department of Electrical and Electronics Engineering, Faculty of Engineering and Technology, JAIN (Deemed-to-be University), Ramanagara District, Karnataka - 562112, India,

[6]Assistant Professor, Maharishi School of Engineering & Technology, Maharishi University of Information Technology, Uttar Pradesh, India,

[7]Centre of Research Impact and Outcome, Chitkara University, Rajpura- 140417, Punjab, India.

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Abstract

The efficiency in merging wireless technology with monitoring health care is considerable since stretchy and wearable antennas have a crucial role to play. Such applications with regards to the healthcare that relies on the designing of this ear piece, where by electrical parts such as connectors, antennas, and circuits are incorporated to provide weightless, data collecting and transferring functions include, all elements of medical diagnostics, fitness and remote monitoring of patients. The integration of IoT in smart health system (IoT-SHS) achieves such goals as enhanced user experience without lowering pain tolerance ratios with high-performance materials and supply chain such as conductive materials and nanoparticles. In smart health care systems the wearable sensors would facilitate monitoring of such parameters as blood pressure, heart rates, glucose level. This allows medical attention to be received more speedily and aids in decreasing unnecessary patient appointments. The data picked up by the antennas parameters up to professionals in the work field making remote diagnosis with specific treatment. Better outcomes for health are also provided by the greater accuracy and reliability of data supplied through the combination of IoT-enabled devices connectable with flexible antennas. This paper presents some of the recent advances in flexible and wearable antennas for effective communication within smart healthcare networks. A perspective on future directions in wearable health technology development as well as the challenges related to design, material selection and integration strategies are presented.

Author's e-mail: prakhar.qsb@quantumeducation.in, shashikant.patil@atlasuniversity.edu.in, poonguzhali.etce@sathyabama.ac.in, sidharthadash@soa.ac.in, g.ezhilarasan@jainuniversity.ac.in, sumukh.panday@muit.in, ansh.kataria.orp@chitkara.edu.in

Author's Orcid id: 0009-0006-0224-3278, 0000-0002-8835-908X, 0000-0003-2147-788X, 0000-0001-7326-3344, 0000-0002-5335-2347, 0009-0005-1102-6892, 0009-0008-9460-8338

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Introduction:

The interface of the wireless technology with the healthcare systems proved to be the most beneficial in terms of the growth of smart health care system.[1] One of the most interesting trends in health monitoring systems is the development of flexible and wearable antennas.[15] These antennas would allow for seamless and continuous transfer of data.[4] Due to their small size, flexibility, and adaptability to fit the human body, these antennas can be highly advantageous for wearable devices such as medical sensors, smart watches, and fitness trackers.[3] Nanotubes and other nanomaterials as well as advanced materials such as conductive polymers and graphene enable manufacturers to produce reliable, aesthetically appealing, and easy to use flexible antennas.[12] The physical characteristics of the wearable medical devices also ensure that there is a high probability that the antennas would work correctly besides the movement or distortion of the patient.[2]

Such antennas could enable a real-time surveillance of critical health such as temperature, concentration of blood oxygen, glucose levels, heart beat rate etc.[6] for advanced health care systems.[5] Such devices allow the late stages of the disease to be reported instead of having to wait till the disease comes to advanced stages, thus serving as a means of preventive treatment.[11] In the process that includes these devices, patients and their imaging specialists can share data almost instantly.[13] Patients are benefiting from early intervention, regular and remote monitoring, and better personalized therapies.[7]

Contribution

- Apart from enhancing the mechanical flexibility and stretchability of the antennas, these materials provide top performance and long-term durability in dynamic surroundings, hence perfect for long-term healthcare uses.[16]
- IoT-SHS demonstrate how flexible and wearable antennas enable wireless communication technologies to be more seamlessly integrated into health monitoring systems.
- Making the healthcare sector an IoT enabling hub depends much on flexible antennas. This kind of antenna enables smart medical equipment to communicate data in real time, therefore enabling physicians to provide remote, customized therapy by means of smart equipment.

The remaining of this paper is structure as follows: In section 2, the related work of Flexible and Wearable Antennas is studied. In section 3, the proposed method of IoT-SHS is explained. In section 4, the efficiency of IoT-SHS is discussed and analysed. Finally, in section 5 the paper is concluded with future work.[17]

Related Work

Machine Learning based Smart Healthcare system (ML-SHS):

The introduction of new mechanism applications is getting greater media attention as healthcare experiences an era of unheard-of digitalization. Including EHRs, telemedicine, mobile health, RPM, and wearables, technology is increasingly being included into healthcare delivery. Wearables and implants are already having a significant impact on healthcare systems all across the globe; new generations of highly sophisticated technologies are providing appropriate answers to the challenges in digital healthcare. Because of their characteristics and flexibility to transmit and receive in different human body regions by Segun, A. et al.,[14] antennas are essential for digitalizing healthcare.

Artificial Intelligence basedSmart Healthcare system (AI-SHS):

With motion of the chest wall, the proposed antenna-sensor—2.4 GHz—can detect breathing patterns. Made of conductive thread and sewed into the material, the antenna is wearable and flexible. Researchers used both theoretical models and numerical 3D electromagnetic simulations to evaluate the antenna-sensor performance [8]. The findings revealed good impedance matching and effective signal transmission and reception capability of the antenna-sensor. Gobinath, A. et al., [9] calculated a SAR value for the proposed antenna-sensor that was found to be lower than the threshold for RF energy exposure regarded safe for humans.

Deep Learning basedSmart Healthcare system (DL-SHS):

Wearable antennas are fundamental component of body centric communication. These antennas have recently grabbed the attention of scientists and gained somewhat popularity due to their pleasing characteristics and possible uses. In the military, healthcare, sports, and identity validation, wireless body area networks (WBANs) serve important purposes. Comparatively to conventional antennas, close closeness to the human body influences the performance of these antennas. As well as return loss, gain, directity, bandwidth, radiation pattern, and efficiency, tissue coupling and absorption influence the Specific Absorption Rate (SAR). Three further design factors that can be absolutely important for these antennas by Ali, U. et al., [10] are size, power consumption, and speed.

Proposed Method:

In an IoT-based smart healthcare system, flexible antennas on wearable devices drives remote patient monitoring. It monitors blood pressure, glucose, vital indicators including pulse by combining medical tools. Cloud systems manage data; wireless technologies subsequently enable distribution of it. Real-time

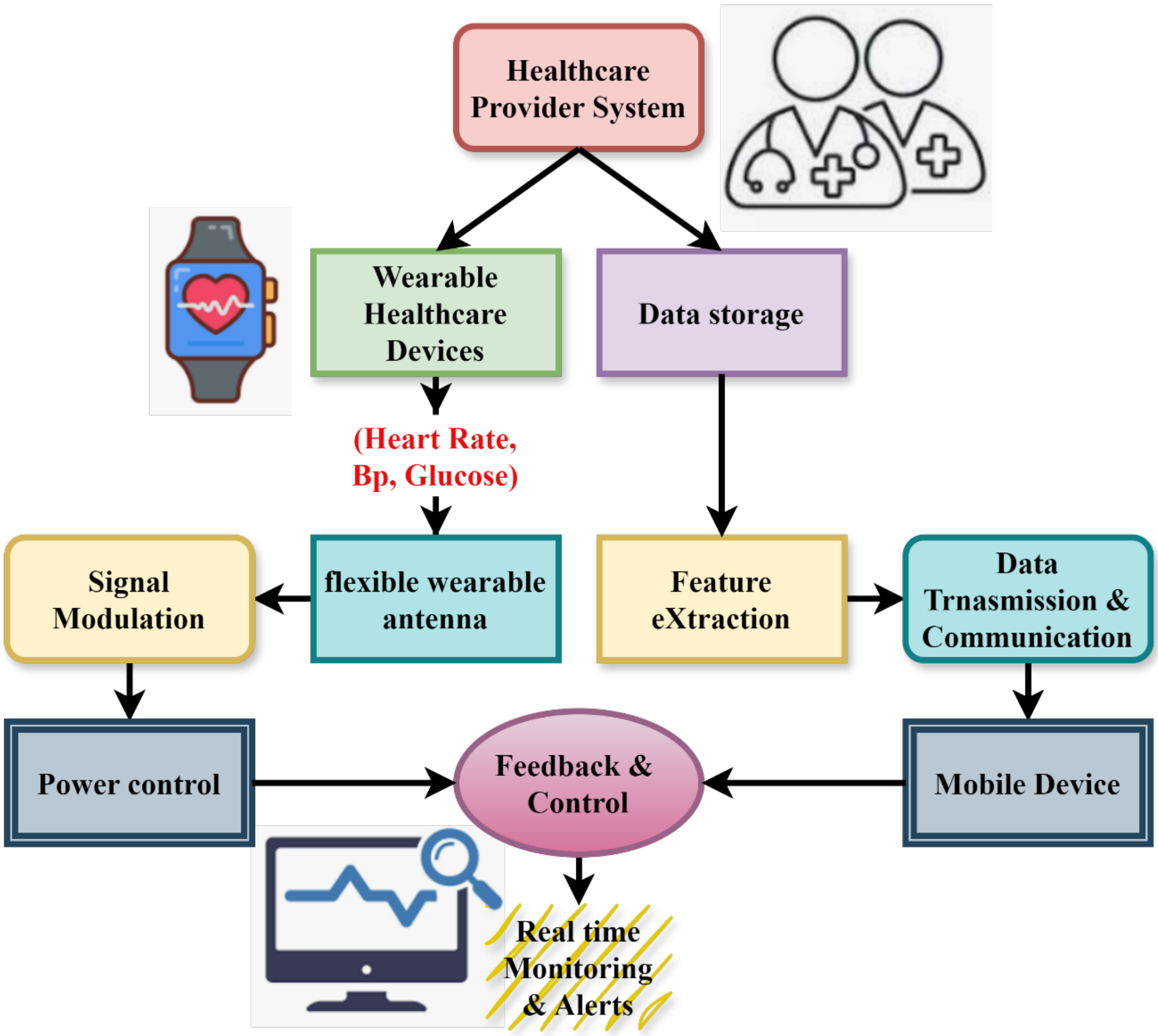

Fig.1: Wearable Antenna in Healthcare Devices

comments provide quick actions, effective power use, and consistent communication.

A smart healthcare Internet of Things (IoT) system meant to make advantage of wearable and flexible antennas. Remote patient health monitoring made possible by the healthcare provider system makes use of a cloud platform and an internet of things gateway. These wearable medical devices track physiological factors like pulse rate, blood pressure, and glucose levels by use of flexible antennas. Once data has been modulated and encoded as signals, data storage and analytics handles it. Data transmission in the Internet of Things (IoT) depends on wireless technologies like Wi-Fi, Bluetooth, and 5G. Techniques for energy harvesting and power control increase efficiency in power use. Figure 1 shows real-time feedback and control to help healthcare practitioners and their patients to have efficient communication.

Combining several medical tools—including thermometers, echocardiograms, and pulse oximeters—the system lets one monitor a patient's health in real time. Among other important measurements, these devices record the patient's temperature, heart rate, and oxygen saturation levels. Before forwarding the signals on to ensure accuracy, a processing unit examines and conditions them. Following processing, the data is delivered across the Internet of Things (IoT), enabling remote patient monitoring by healthcare providers. Patients and medical professionals may monitor vital signs and other health indicators by means of the Mobile Monitoring app. Signal generating technologies enable timely interventions; likewise, they provide reliable communication and efficient transmission demonstrated in figure 2.

The approach provides continuous health monitoring by means of wearable devices using bending antennas.

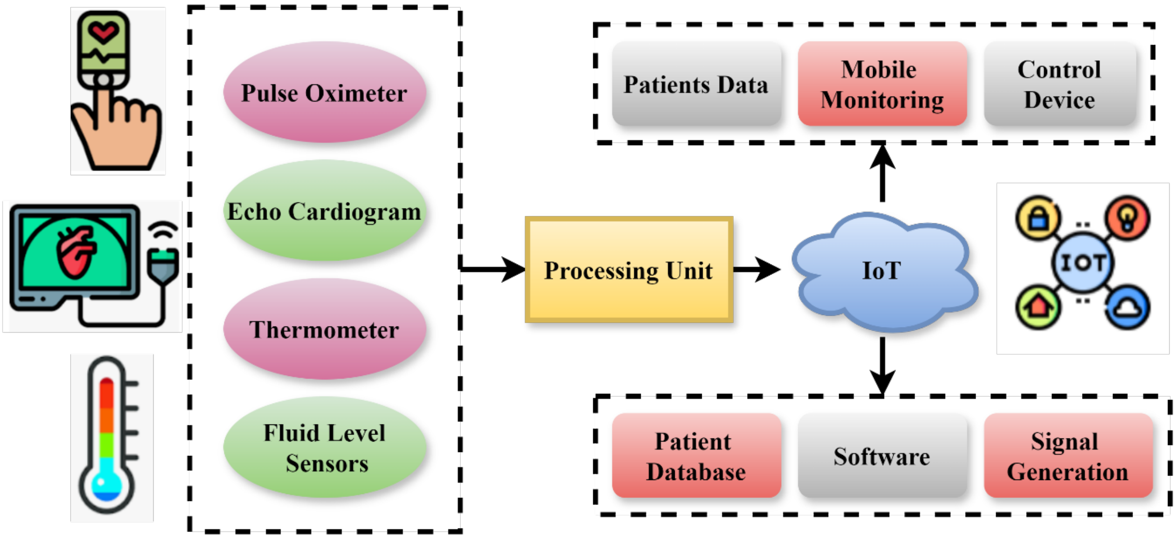

Fig. 2: Real-Time Health Monitoring System Using IoT

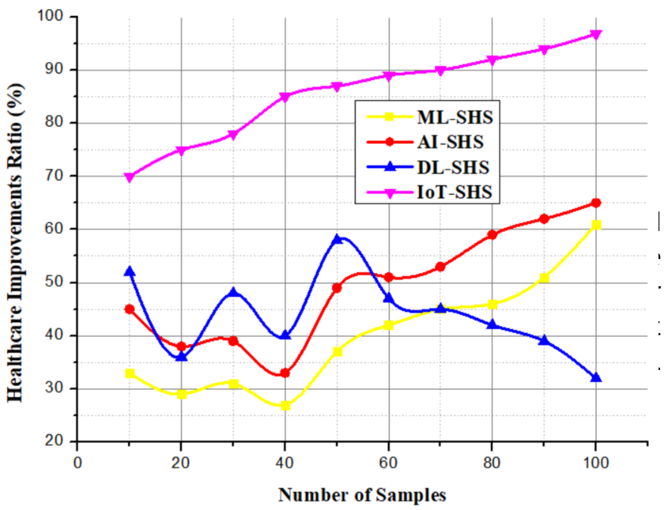

Figure 3: Analysis of Healthcare Improvements

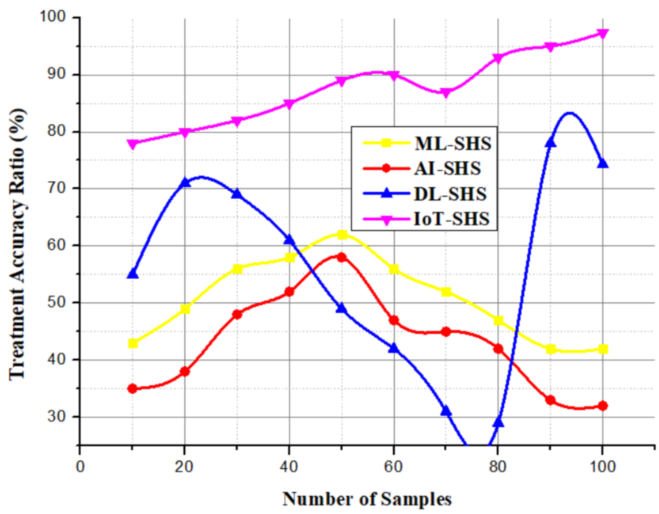

Fig. 4: Analysis of Treatment Accuracy

Smart healthcare solutions employing flexible and wearable antennas greatly improve patient care by allowing continuous and real-time monitoring of important health data. Early problem detection made possible by this technology allows customized treatment programs, remote medical professional monitoring, Reducing healthcare expenses, increasing the use of preventative treatment, and streamlining data exchange between wearable devices and healthcare professionals helps to improve patient outcomes and efficiency of healthcare delivery.

Smart healthcare systems using flexible and wearable antennas significantly increase the accuracy of therapy by allowing continuous and real-time monitoring of patient health data. These antennas guarantee that data provided by wearable devices reaches doctors regularly and without mistake, therefore allowing quick and precise diagnosis. By means of healthcare providers, real-time data on important indicators including heart rate, blood pressure, and glucose levels may rapidly satisfy patients' specific demands. The ability of this technology to increase intervention accuracy, reduce human error, and provide more focused and effective therapies helps to enhance patient outcomes.

Conclusion:

Flexible and wearable antennas are essential for the development of smart healthcare systems to provide reliable, real-time data transmission in health monitoring equipment. Designed from flexible materials including conductive polymers and nanomaterials, these antennas provide the long-term performance, comfort, and durability needed for wearable technologies. They provide early identification, customized therapy, and speedy interventions by means of seamless connectivity between healthcare equipment and professionals, therefore providing remote monitoring of key health indicators.IoT systems may be even more effective when flexible antennas are combined with them. This helps in smart healthcare. From this follows better data flow and healthcare delivery. Though material choice and antenna design provide significant difficulties to be addressed, these developments offer considerable promise for enhanced patient care, lower healthcare expenses, and more advocacy for preventative healthcare. Just two ways flexible wearable sensors are already revolutionizing healthcare and will continue to do so as technology evolves are improved patient outcomes and more efficient healthcare administration.

Future Work: Improving performance, decreasing power consumption, and integrating with new wearable healthcare technology will be the goals of future research into flexible antenna design and material optimization. More sophisticated Internet of Things (IoT) connection technologies for smooth, real-time health data exchange and monitoring will also be the focus of future study.

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