

Miniaturized Skin-Integrated Electronics in Real Time for Virtual Assistance - A Review

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Abstract

The skin acts as a conduit between the brain and the outside environment. The information it receives, such as a touch on the shoulder or the heat from a fire, is processed and used to choose an appropriate response by the brain. A skin functionality may be achieved by incorporating sensors onto bionic skins that are on par with the sensitivity of biological skins. However, doing so is not simple. Recent developments in physiological sensing, sensory perception, and virtual and augmented reality are discussed, as are other intelligent uses of skin-integrated electronics. These skin-integrated systems are advancing the materials and structural designs necessary for the next generation of electronic eyes, ears, and skin. Future progress in this area of study will be aided by interdisciplinary exploration into fields such as materials science, electrical engineering, mechanics, and biomedical engineering.

Keywords: Electronic skin, wearable device, artificial skin, biophysical sensors, biochemical sensors

1. Introduction

1.1 Electronic Skin

The field of electronics has been crucial in the creation of seemingly inconsequential gadgets for almost every application. As a result, electronic tools are essential in every industry. The finest medical use of integrated electronics in the future will be artificial skin. These electrical components are very thin [1-5]. The gadget, which is attached to the skin and appears like a weird tattoo, can detect electrical activity in the heart, brain waves, and other

important signs. A deeper understanding of their surroundings is essential for robots to progress in their development. Temperature, touch/pressure, and airflow are all perceived by the human body via the skin. Sensors built on flexible substrates with the ability to conform to curved surfaces are the end aim. Artificial skin is being developed by scientists with the hopes of revolutionising the fields of robotics, medicine, and flexible electronics. Since skin is such a vital organ, artificial skin may be customized as shown in figure 1, and it is to take the place of biological skin. The primary purpose of synthetic skin is to mimic the sensations of real skin, including heat, pressure, touch, airflow, and more. It may take the place of mechanical arms or prosthetics [6-11].

1.2 Artificial Skin

Prosthetic limb users now have access to another kind of "artificial skin" made from flexible semiconductor materials that can detect touch. It is hoped that the artificial skin would aid robots in doing routine tasks that humans would regard to be particularly delicate and that need them to have a deft touch. Using an electrode arrangement in which electrical charges are stored inside the artificial skin, scientists discovered that even very little pressure could be sensed by placing a layer of rubber with two parallel electrodes. In order to measure the amount of force applied, electrodes are placed in contact with the rubber and monitor any changes in electrical order caused by the applied force. When pressure is applied to the skin, the layer is so thin that the molecules are trapped and entangled. When the pressure is removed, the molecules do not go back to their original states [12- 14].



Figure 1. Sample Artificial Skin

1.3 Biological signal detection

The human body is a highly specialised biological system that controls a wide variety of highly coordinated physiological functions. Therefore, it is crucial for medical treatment to be able to detect biophysical and biochemical signals deep inside the body through the body's

surface. The monitoring of physiological signals in clinical settings over extended period of time in real time is also included. However, most of the monitoring systems now used in clinical settings depend on bulky machinery that isn't suited for continuous and real-time patient monitoring. Multiple biological signal detection may be accomplished with the use of electronic equipment that are lightweight, flexible, and portable. This has resulted in flexible electronics gaining a lot of attention and eventually being indispensable in the field of healthcare monitoring.

1.3.1 Flexible electronics

In terms of portability and wearability, flexible electronics excel because of their pliability and stretchability. Advantages in developing bio-degradable and bio-compatible materials, deploying wireless communication/power strategies, and exploring structural designs are driving new applications in wearable and implantable flexible electronics. These applications include neural interfaces, genetics, tumour targeting biopsies, and physiological signal monitoring.

1.3.2 Ultrasonic sensor

In order to keep both robots and people safe, ultrasonic sensor arrays covering enormous areas have been created. An ultrasonic skin covering the whole robot's exterior, for instance, may function as a proximity sensor in all directions. This may keep it from slamming into walls or make it gentler while handling human bodies. This technology has the potential to create prosthesis and clothing that are keenly aware of their environment. Improving electrical features, such as the speed with which data can be received from the sensors, is just as important as adding new functionality to skins. Some researchers are working to develop stretchable materials that don't restrict electron movement, since this is a key limiting issue [15].

1.4 Motivation

Multifunctional sensing capabilities, or the ability to detect many kinds of inputs at once, is an important feature of a cutting-edge electronic skin. More specifically, e-skins that can detect pressure and temperature concurrently are useful for defence, touch identification, and manipulation [16]. Making an e-skin that is both highly responsive to a variety of stimuli and has a broad linear response range remains challenging.

2. Literature Survey

An electronic eye with a hemispherical retina based on a dense array of perovskite nanowires was suggested by Gu et al. With a pitch of 500 nm, the single-crystalline perovskite nanowires may achieve a density that is in orders of magnitude more than that of the photoreceptors in the human retina, suggesting they have the ability to record pictures with a high degree of detail. This bio-mimetic layout provides a springboard for engineering an electronic eye [17]. Stress may be mitigated with the use of an MHVA, as shown by Yorita, Egerton, Oakman, Chan, and Kubota [18]. The three models that make up its conviction, desire, and intention catch were considered.

In that regard, Park and his colleagues at their university have achieved notable achievement. They discovered that they could print semiconducting nanowires onto plastics and paper, allowing them to create flexible, large-area electronics. Unfortunately, despite their high electron mobility, nanowires have not yet been used in large-area electronics. Javey's materials will pave the way for exciting new uses of e-skins [19].

The ability of flexible biophysical sensors to detect Electroencephalogram (EEG) is remarkable. However, the widespread application of continuous real-time EEG readings for medical diagnoses and sleep monitoring is hampered by the fact that traditional EEG recording devices are not lightweight and often use hard components to build physical interfaces with the skull. For this reason, several scientists have been studying application in the domain. Biopotential electrodes that did not need any special skin preparation or attachment pressure were created by Flurin Stauffer et al. In order to achieve a reliable ECG while practicing in water, a professional swimmer was able to use polymer electrodes [20].

The human-inspired virtual assistant is distinct from its analytical counterpart since it has both emotional and cognitive intelligence. Because of this, such an entity performs every task associated with an analytical assistant. As a result, a virtual assistant that takes inspiration from the human experience may recognise and account for the impact of emotions on people's choices.

2.1 Summary of the Problem Statement

The presence of cognitive intelligence separates analytical virtual assistant from an expert. This helper remembers the things it's done before, and that knowledge informs its present and future choices. Even more impressively, an analytical virtual assistant can create a conceptual model of real-world operations.

3. Sensing devices for E-Skin

3.1 Biophysical Sensing Devices

As human civilization has progressed quickly, so has the interest in tracking infectious diseases and keeping tabs on health issues. Physiological parameters such as the Electrocardiogram (ECG), Electronic Acoustics (EA), Pulse Rate (PR), Body Temperature (BT), and Respiration Rate (RR) can be detected and analysed with high accuracy by skin-integrated electronics due to their flexibility and stretchability, which allow for good contact with the skin. Skin-integrated sensors have a wide range of potential applications due to their low weight and small size. Due to this, they are well-suited for continuous illness surveillance and health monitoring [21].

3.2 Bio-sensing devices

Sweat is a liquid that is produced by the skin's many sweat glands. Electrolytes, nitrogenous substances, metabolites, hormones, and xenobiotics are only some of the molecules and physiological information that may be found in eccrine sweat. Diseases, metabolic abnormalities, and mental ailments are all linked to elevated levels of these substances in the sweat. Examples include the correlation between blood ethanol and sweat ethanol concentrations, the potential qualitative indication value of sweat glucose levels, and the ability to detect both physical stress and the transition from aerobic to anaerobic states on the basis of sweat lactate concentrations [22]. The most reliable indicator of cystic fibrosis is an unusually high quantity of chloride in sweat; other common diagnostic markers include uric acid (renal illness, gout, etc.), urea (kidney failure), and tyrosine (tyrosinemia, liver disorders, etc.). Figure 2 shows some flexible bio sensor devices.

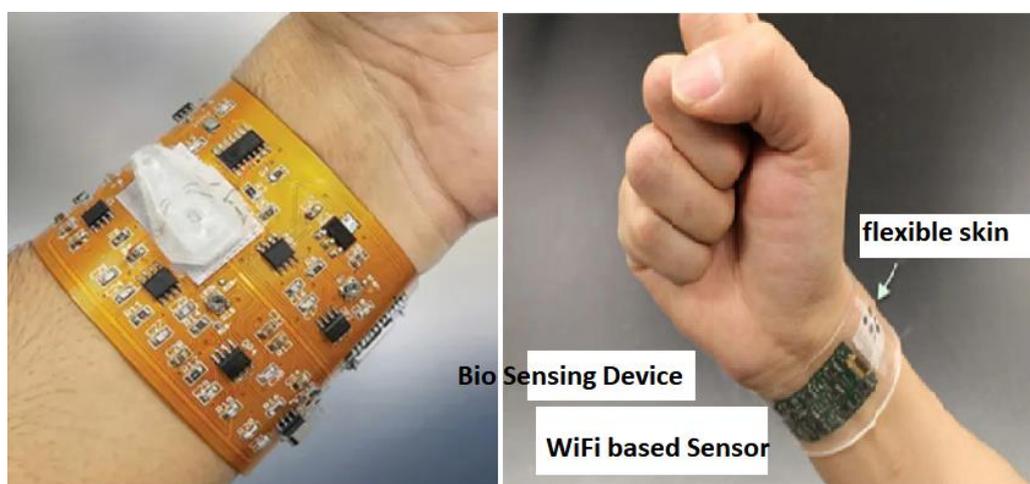


Figure 2. Bio-sensing devices

3.3 Detector based on electrochemical reactions

Electrochemical sensing electrodes fabricated from carboxylate-rich pyrrole derivative grafted and later modified graphene were used to detect cortisol. The scientists used this skin-integrated electronic/microfluidic device to constantly monitor the dynamic stress-response profile of cortisol levels and conduct a thorough study of the link between cortisol concentration in sweat and serum. A Bluetooth Low Energy (BLE) module handled the signal processing and wireless transmission on the device. So, the little gadget was made out of a sturdy but compact Printed Circuit Board (PCB) and a flexible sensor [23].

3.3.1 Devices with Embedded Sensors on the Skin for Healthcare Monitoring

Health indicators that are based on a person's physiological state are crucial. Skin-attached, ultra-thin sensors may provide continuous, real-time health data. Recent reports and applications of skin-integrated electronics for physiological sensing are presented here, including details on the materials, devices, and integration methodologies used. Based on the characteristics of the signals, skin-integrated biophysical and biochemical sensors are explored. Temperature, pressure, and strain are just some of the data that biophysical sensors may collect. Body fluids such as perspiration and blood are detected and analysed using biochemical sensors [24].

3.3.2 Integration of Ambient Intelligence

Physiological data collected by PerMEASS from a smart wristband (the Empatica [12]) is being tested (e.g., heart rate, sweating rate, and skin temperature). The Seasonal Affective Disorder (SAD) is automatically monitored using these readings [14]. By feeding the data from the bracelets into a neural network to create a model that can anticipate a user's SAD symptoms, PerMEASS may avoid or reduce the frequency with which it asks users to fill out the SAD questionnaire, therefore providing a better experience for the user.

As a result, the user model is constantly refreshed with current SAD ratings. The SAD model is constructed in such a manner that, at the beginning of the measurements, the questionnaire responses are utilised to assign labels to the smart bracelet's physiological data. As the quality of the model increases with more data, customised ML models are eventually developed that are capable of accurately predicting SAD scores [25]. Therefore, it performs on-the-spot analysis of perspiration during strenuous physical activities like cycling or running, without requiring a remote computer.

3.3.3 Skin temperature

A person's temperature is a clear indicator of whether they are experiencing a fever or not. Predicting illnesses may be improved by collecting more detailed information about the human body, and one way to do this is by measuring the skin temperature of particular body locations. In order to keep tabs on one's core temperature, one may simply insert a small commercially available or homemade temperature sensor onto a flexible circuit. In addition, temperature changes may alter the static pressure's P mode. Since the reaction time for static pressure is much lower than the response time for temperature, additional research would attempt to make up for this by inventing more algorithms.

3.3.4 Characteristics consideration

Innovative micrometer-scale pyramidal structures in the thin rubber layer expand in response to the weight of a fly, allowing the material to be used for this purpose. Such patterns might be placed in bionic skin to allow the detection of air movement such as a breath or a wind. Such sensitivity would be especially useful in a prosthetic hand, allowing the user to grasp and hold even the most delicate things. Although they rely on composite materials that boast conductivity, flexibility, and resilience, the reading interface and signal processing of e-skin devices have received very little attention throughout their development.

4. Conclusion

By connecting skin-integrated electronics to a device that can monitor the user's vitals in real time, the assistant may be used to explore uncharted territory in the field of assistive technology. The next steps include putting the plan into action and putting it through its paces in randomized controlled trials. Screens, both real and virtual, may soon be embedded in gadgets that track our vitals, and may be used for smartwatches, interactive wallpaper, and automobile displays.

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