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Technical Review of Wearable Non-invasive Sensors Available Today

Introduction

There is a current need for wearable devices that can be used to monitor patient health in real time and provide a safety net system that alerts caregivers to potential danger. These devices utilize non-invasive sensors in order to detect and report a wide variety of physiological parameters.

Commercial Applications of Wearable Devices

1. Fitbit

One of the more popular commercial products that are "health-aware" is the Fitbit. The Fitbit is a battery operated device housed within a flexible rubber shell that is worn around the wrists like a watch [1]. The Fitbit is then able to measure various parameters such as steps taken, calories burned, and heartrate [2]. The market for the Fitbit is aimed towards individuals who do not need intensive care. Its purpose is to provide customers data that is relevant to their health. This device was not intended to be a diagnostic or caregiver tool and has a price point of 200 USD [2].

2. Perspiration Patch

Contrary to the Fitbit above, the perspiration patch [3] developed by the University of Cincinnati is directly meant to be used as a diagnostic tool. This device is shaped like a band aid and is attached directly onto the temple with a sweat-porous adhesive. The patch is a monitoring device that analyzes the biological composition of patient sweat in real time. By comparing the imbalance of certain ions or electrolytes, the administering caregiver is able to diagnose certain correlating illnesses. This patch is meant to be sold to researchers at a price point of about 90 USD [3].

Technologies of Wearable Devices

1. Optical Sensors utilizing the Photoplethysmography technique

Many of the devices today use optical sensors sandwiched between body tissue. The device then detects light attenuated by the body tissue using a photodiode and has the signal processed [4], [5]. By knowing the photodiode's sensitivity (or transduction gain) the output voltage range can be controlled and measured [6]. Typically, the output voltages are anywhere from 1 mV to 1 V. This so-called photoplethysmography technique is used to measure patient heart rate and is the most widely used technique in modern wearable devices.

2. Sweat Sensors Utilizing Microfluidic Chips and Analysis Techniques

The sweat of a patient contains much information that is pertinent in the diagnosing realm. By knowing the makeup of said sweat, many diseases, such as cystic fibrosis [3] can be detected. The particular patch developed by the University of Cincinnati uses a paper microfluidic in order to separate the different ions and electrolytes contained within the sweat. The movement of the liquid that flows through the sweat-porous adhesive is controlled by the paper-based microchannels through capillary action [7]. As the different ions and electrolytes of the sweat are separated, each distinct element flows into a micro reservoir. A light is then shone through the micro reservoirs and the concentration of the elements measured by the way the light behaves.

Building Blocks of Wearable Devices

1. **General Composition of Wearable Devices**

   At the bare minimum, modern wearable devices utilize a portable sensor that can be advantageously positioned on at patient's body in order to accurately measure and report a biopotential.

2. **Signal Processing and Power Considerations**

   All wearable devices within this health-aware realm must do signal processing in order to refine and make use of the data that is measured. Most of the time, the processing is done on the device using a microprocessor. Because the devices are meant to be worn daily and be portable, there are significant constraints on power usage when doing said signal processing. Battery capacity is seen to be limited to 2600mAh in the market today [8].

References

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