Non-Contact Vital Sign Monitoring

Introduction

Although vital signs provide critical information in determining a patient's current state of health, they are not always measurable using conventional methods [1]. For infants, elderly, or patients suffering from burns, health care providers experience difficulty continuously measuring the blood pressure, temperature, respiration rate, or heart rate of patients, which can identify the existence of an acute medical condition, help to rapidly quantify the magnitude of an illness, and act as a marker of chronic disease states [2]. As a result, researchers and health care providers developed ways to measure vital signs without invasive contact with the patient's body. This paper is a review of technologies associated with methods currently utilized to provide non-contact vital sign monitoring and the impact these technologies would have in patient care globally.

Camera-Based Non-Contact Vital Sign Monitoring

Since the 1930s, it has been known that the variations in tissue blood volume in a body segment, with each heartbeat, modulate the transmission of visible light through or from that body segment [3]. This light transmission or reflectance is known as the photoplethysmographic (PPG) signal, which can be utilized to measure the heart rate, respiration rate, and blood oxygen level of a patient [3,4]. Recently, researchers have been able to accurately measure the PPG signal of subjects with a digital video camera up to two meters away from the subject, using only ambient light as the light source [3].
Researchers at Rice University were able to determine the heart rate of a subject using a monochrome camera and a PPG estimation algorithm they developed by measuring the change of hemoglobin and oxyhemoglobin in any area of a subject's face [4]. Although the study needs more data to prove that this method is viable for long-term monitoring, the results, with respect to the technology used to conduct the study, are promising. With the average cost of a monochrome camera ranging from $7,000 to over $40,000 in an age where the price of technology decreases rapidly as new technology is developed, this technology could replace the monitoring equipment in hospitals that range from $20,000 to $30,000 per setup [5,6].

Under-the-Bed Noncontact Sensors

With elderly care and long-time monitoring as customer requirements to measure vital signs, muRata, an electronics company, developed an accelerometer-based ballistocardiographic (BCG) signal sensor that is attached under a patient's bed to measure vital signs continuously [4]. It works by capturing the vibrations on the bed caused by a patient's heart rate, respiration, and body movement using an ultra-

sensitive accelerometer and using a microcontroller to process the information and produce the measurements [4]. The solution includes a PCB module that contains the accelerometer and the microcontroller for BCG algorithm processing and it also includes a PCB module with the bonus of WiFi connectivity for ease of integration [7,8]. The modules are sold in units with prices ranging from $106.82 to $137.84 per unit for the PCB module and $170.92 to $198.88 per unit for the PCB module with WiFi according to prices listed on Digi-Key's site.

Doppler/Radar Non-Contact Vital Sign Monitoring

Microwave Doppler radar has gained popularity in wireless sensing applications, including volume change sensing, life detection, and cardiopulmonary monitoring, which has propelled in interest in non-contact vital sign monitoring [9]. The Doppler radar first transmits a radio-frequency continuous wave quadrature signal captures the signal once it has been reflected off of the human body []. After the signal is amplified and down-converted, the signal is phase modulated by the physiological movements, and then the human heartbeat and respiration rates are identified by processing the baseband signal using advanced signal processing techniques [9]. A biomedical company, SENSIOTEC, has developed an Impulse Radio Ultra-Wideband sensor using this technology, but it is not widely available due to expensive and specialized hardware [4,10].

The Potential Impact of Implementation

The impact of the implementation of non-contact vital sign monitoring technology expands across homes and industries globally. The implementation of this technology will protect infants in the Neonatal Intensive Care Unit (NICU), who often suffer from skin damage as a result of requiring electrodes, adhesive tapes, other probes to continuously measure vitals, but it could also protect infants in their homes by helping to prevent Sudden Infant Death Syndrome (SIDS) [4,10]. This technology can also provide health care aid in third world countries where supplies are limited and risk of disease or infection is increased. Car manufacturers are also interested in utilizing this technology to prevent accidents caused by drivers that are sleepy, under the influence, or suffering from seizures or heart attacks [11].

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