Design of a Artifact-Free Wearable Plethysmographic Sensor

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Abstract The ring sensor is a compact, wearable device that was originally designed for continuous physiological monitoring of a human body. In this paper, we propose a new design of the ring sensor that can alleviate the artifact of motion and ambient light significantly.

Keywords : photoplethysmography, motion artifact

1. Introduction

A 24-hours patient monitoring device called "Ring Sensor" has been developed by the authors [1]. The Ring Sensor is a miniaturized telemetered ambulatory monitoring device in a ring configuration by combining the technology of pulse oximetry with microelectronics and wireless communication technologies. The Ring Sensor, however, is inevitably susceptive to a variety of motion and ambient light artifacts. For example, in a highly accelerated motion of the patient, the inertia force causes the optical sensor unit to move or slide on the skin surface, and, as a result, the optical sensor measurement would be distorted or even ruined completely. Even a static external force causes a similar distortion of the measurement due to the relative displacement of the sensor to the finger. In addition, ambient light is another major source of the artifact on the optical measurement. Therefore, to guarantee stable and clear signal measurements, it is necessary to develop a new design of a ring-shaped device that can minimize the influence of mechanical and optical disturbances on the signal detection.

2. Design

This newly designed ring sensor is composed of two separate rings. The inner ring, made of compliant material, carries a tiny optical sensor unit for measurement, and the outer ring carries relatively bulky circuit board that includes a CPU, a signal processing module, an RF transmitter, and a battery. These two rings are mechanically isolated from each other except a few thin wires for the electric signal transmission. With this configuration, the inertia-free inner ring with the sensor unit maintains a tight contact with the skin surface even in a highly accelerated motion, resulting in reliable, consistent measurement. The outer ring, on the other hand, works as a mechanical shelter and prevents external force and mechanical contact from influencing the measurement of the sensor unit. Fig 1 shows how this new design can alleviate the influence of external force on the measurement. The sensor unit can still maintain tight contact with skin under an external force applying on the ring, since the external force is mostly sustained by the outer ring and the finger surface away from the measurement point. In addition, the outer ring works as an optical seal to block the ambient light, generating more accurate optical measurement.

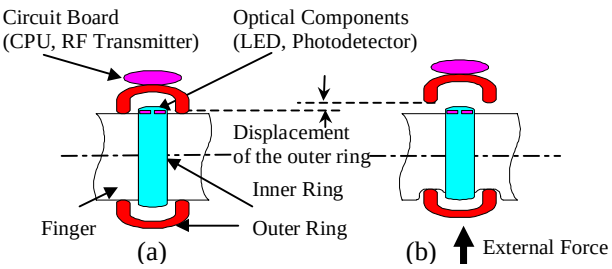

Fig 1 : New Design (a) No external force applied
(b) External force applied on the bottom of the ring

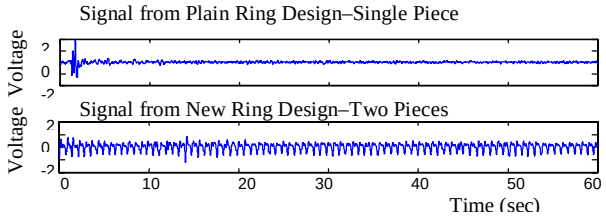

Fig 2 : (a) Comparison of measurements from a single-piece plain ring and the newly designed ring with an external force on the opposite side of the sensor unit

3. Experiment Results

Fig 2 shows the comparison of the measurements from a plain, single-piece style ring sensor and the newly designed ring sensor in the presence of an static external force applying on the opposite side to the sensor unit. The measurement from the plain ring does not show a recognizable pulse signal, mainly due to the air gab caused by the external force. On the contrary, the measurement from the newly designed ring sensor clearly shows the human pulse.

4. Conclusion

A new design of the ring sensor that can minimize the influence of mechanical and optical disturbances was presented. The experiment result supported the validity of this design.

Reference

[1] Rhee, S., Yang, B-H. and Asada, H., "The Ring Sensor: a New Ambulatory Wearable Sensor for Twenty-Four Hour Patient Monitoring," Proc. of the 20th Int. Conf. of the IEEE EMBS, Hong Kong, Oct, 1998