

Chapter 26

Non-Contact Pulse Monitoring Using Live Imaging

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ABSTRACT

In this paper, the authors describe a novel non-invasive technique for monitoring pulse rate using live imaging. This method is based on the finding that brightness of the skin varies with pulsation due to the effects of blood scattering. The technical methods for image capture and data processing are described. The mechanism of light reflection inside the skin is also described using a layer model consisting of stratum corneum, epidermis, and dermis. This non-contact measurement method can yield natural physiological data during regular daily activities, and thus appears suitable for in-home healthcare monitoring.

INTRODUCTION

Given the ongoing aging of societies worldwide, care must be taken at home and in community dwellings to maintain and improve quality of life in the elderly both for disease prevention and health management. For this purpose, a number of in-home health monitors have been proposed (Yamakoshi, 2000; Ohta, 2002). Considering that home monitors will be used by many who are unfamiliar with new or advanced technologies, they must be convenient, even for individuals without prior experience operating such devices.

In addition, the monitors should be non-contact or non-invasive; as aging dwellers are notably uncomfortable with being monitored by novel devices, and data collected by intrusive methods might differ from those observed during normal daily activities. If complicated interaction with these monitors is required, physiological data under natural unobstructed conditions might not be obtained.

To overcome this obstacle, a sensible approach for natural human data collection would ideally be built into a dwelling environment, in the form of a residential space embedded with sensors aimed at remote monitoring, emergency detection, and improvement of residential quality of life. With

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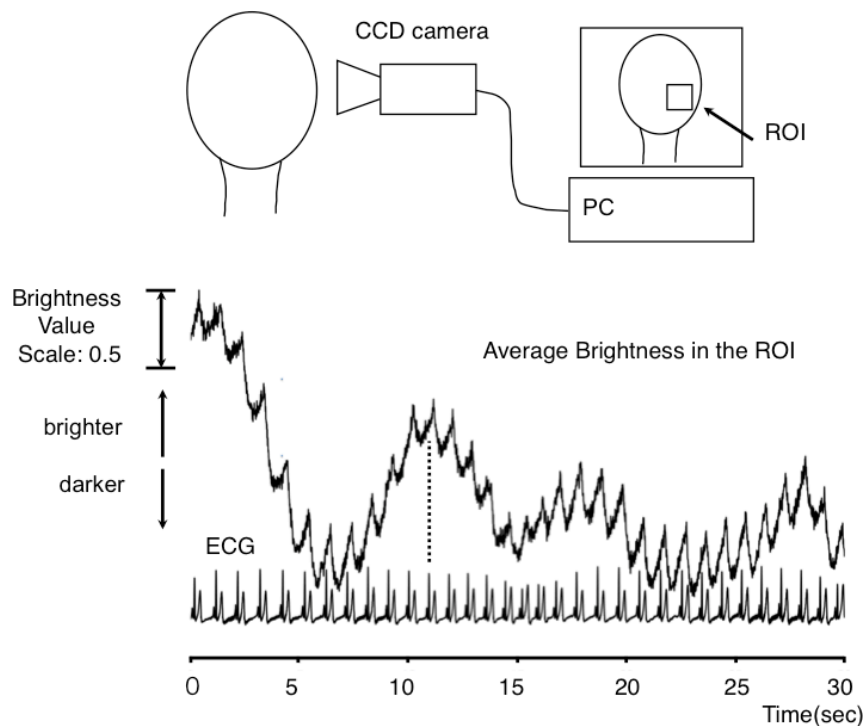
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such ambient monitors, data could be collected from dwellers unobtrusively and would reflect natural daily activities (Ohta, 2009). Studies of dwellings based on this idea, known as “Smart Homes,” have been activated in recent years around the world with remarkable results (Smart Homes Website). Another healthcare monitoring technique involves the use of a wearable device; by creating data logging devices that are small enough to wear conveniently, natural data can be collected throughout daily activities. For example, a wearable shoe device to monitor gait and prevent falls has been developed to measure plantar pressure in real-life conditions (Saito, 2011). The device consists of a shoe insole with seven pressure-sensitive conductive rubber sensors and a wireless data transmission unit that is incorporated into a smaller measurement unit. This in-shoe

device can be used to monitor plantar pressure during daily living and is expected to prove useful in various clinical applications. Another typical non-invasive measurement technique involves combining imaging with highly advanced PC technologies. Applying the feature of non-contact measurement, various camera monitors have been developed to data (Nakajima, 2001; Cala, 1996), including a CCD camera for collecting heart and respiratory rate simultaneously (Takano, 2007).

Figure 1 shows a schematic diagram of the system used in the present study. Live images of the subject were captured by a CCD camera for approximately 30 seconds, and the region of interest (ROI) was set on the cheek area of the facial image. Changes in the average brightness within the ROI were calculated, and the data were processed by a series of operations of interpola-

Figure 1. System configuration and a typical example of changes in brightness value within the ROI. Live images of the subject were captured by a CCD camera for approximately 30 seconds, and the ROI was positioned on the cheek area of the facial image. Changes in brightness within the ROI were calculated and are shown in the chart. The curve includes two types of waves representing heart beat and respiration. When blood flow increases after the R-wave of the ECG, brightness decreases (broken line).



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