MATHEMATICAL MODEL FOR UNCONSTRAINED VIBRATION MEASUREMENT DEVICE TO ESTIMATE SCRATCHING TIME DURING SLEEP FOR DIAGNOSIS OF ATOPIC DERMATITIS

Keita Nishio, Takashi Kaburagi, Satoshi Kumagai,
Toshiyuki Matsumoto and Yosuke Kurihara
Aoyama Gakuin University

ABSTRACT

In a medical setting, the total scratching time (TST), measured using an infrared camera during sleep, is used to diagnose atopic dermatitis. Because the camera invades patient privacy, accelerometers, strain gauges, and gyro sensors have been proposed as privacy-conscious methods. However, these devices must be attached directly to the patient's hand and thus, they restrict movement. To estimate the scratching time without any restrictions to the patient's movement, we designed a measurement device based on piezoelectric ceramics and constructed a mathematical model of the device to clarify its characteristics. We also developed an algorithm to calculate the TST based on the output from the measurement device. This device consists of a circular piezoelectric ceramic, two disk-shaped metal plates, and a cylindrical spacer. The two metal plates sandwich the spacer, and the piezoelectric ceramic is bonded to the inside of one of the plates. One measurement device is set under each leg at the head of a bed, and they flex due to the weight of the bed. A mathematical model between the input force due to the vibration generated on the bed and the output signal from the measurement device can be characterized by an equation of motion for the plate and ceramic, the electric charge in the ceramic, the piezoelectric effect, and the reverse piezoelectric effect. To calculate TST from the output signal, the wavelet transform and non-negative matrix factorization are applied. The results indicated that an accuracy of 0.97 was achieved in estimating TST, which validated the method.

Keywords: non-negative matrix factorization; piezoelectric ceramics; skin disease; total scratching time; wavelet transform