Automatic Scratching Time Estimation System for Piezo-electric Ceramic Sensor Utilizing Hidden Markov Model

Kazutoshi Shiba, Takashi Kaburagi, *Member, IEEE*, and Yosuke Kurihara, *Member, IEEE*

***Abstract*—Itching is a symptom of various diseases and patients scratch their skin for relief. One of the measures used to objectively evaluate the pruritus is called the total scratch time (TST). In this paper, we present a system utilizing the Hidden Markov model (HMM) to estimate the scratching time considering a time series signal of a piezo-electric ceramic placed under the leg of a bed. The preliminary experiment resulted in an accuracy of 95.1%.**

I. Introduction

Itching is a symptom of various diseases and patients scratch their skin for relief. However, repeated scratching will result in damaged skin [1]. Scratching during sleep, known as nocturnal scratching, is especially important since the patient cannot suppress the desire to scratch. Therefore, the level of pruritus is often measured by the total scratching time (TST) during night. Although various sensing devices such as infrared camera [3], accelerometer on the wrist [2], and piezo ceramic under the bed [4] have been proposed to detect the scratching movement, these methods require visual confirmation to obtain the scratching time. An automatic method to determine the TST from sensing devices is required to improve efficiency. In order to incorporate the temporal dependencies into the action of scratching, in this paper, we propose a system utilizing the Hidden Markov model (HMM) to estimate the scratching time considering a time series signal of a piezo-electric ceramic proposed in [4] placed under the leg of a bed.

II. Proposed Method

Fig. 1 shows the schematic overview of the proposed system. First, the signal detected by the piezo-electric ceramic sensor $x(t)$ is digitized to $x(k)$ where t denotes continuous time and k denotes discrete time. The wavelet transform with Meyer mother wavelet function is performed to obtain the time-frequency domain data $W(k,f)$. The average amplitude at each time point is calculated as $\mathrm{A(k)} = \sum_f W(k,f)$ and the moving average over 25 time points $\mathrm{O(k)} = \sum_{k-24}^{k} A(k)$ is obtained. For each time point of $O(k)$, an underlying hidden state sequence $Z(k)$ is assumed to exist. Each $Z(k)$ is associated with one of three types of movement: stable, moving a hand, or scratching. Considering a sequence of O(k) where the TST is unknown, the model first calculates a maximum posterior state sequence $\hat{Z}(k)$. The system re-labels $\hat{Z}(k)$ using one of the three types of movement (stable, moving a hand, or scratching) and obtains $\hat{S}(k)$. The TST is calculated by the length of $\hat{S}(k)$ when the movement is labeled as scratching.

III. Experiment

We performed a preliminary experiment with six subjects to evaluate the feasibility of the proposed method. The subjects would lie calmly on a bed and a piezo-electric ceramic sensor would be placed under the leg of the bed as described in [4]. Within 30 s of observation time, each subject would begin and finish scratching his/her cheek. Five trials were performed for each subject. We performed a cross validation for each subject separately in order to evaluate the proposed method; we used a trial for testing and the other four trials for learning. The performance of the system was evaluated by the accuracy of labeling of the scratching action at each time point.

IV. Experiment Result and Conclusion

The overall accuracy was 95.1%. Although the method showed encouraging results, it should be tested on a larger dataset and more analysis on the effect of state selection should be performed.

References

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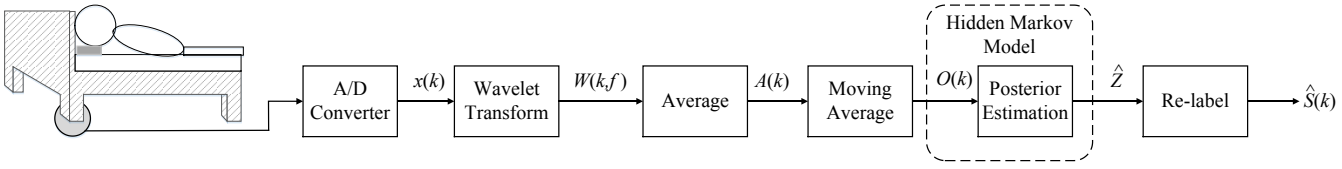

Figure 1. Overview of our proposed system.

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K. Shiba, H. Iwasaki, M. muto, T. Kaburagi, and Y. Kurihara are with Aoyama Gakuin University, Kanagawa 252-5258, JAPAN (Phone: +81-427-59-6372; e-mail: kaburagi@ise.aoyama.ac.jp).