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Measurement of Sleep and Understanding of Sleep Apnea in Video

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Abstract

A person sleeps a third of his or her life, which means that a person sleeps seven or eight hours a day. However, many people suffer from disturbed sleep. In this paper, we try to segment a video into shots using the method of Bhattacharyya Distance. After analyzing these segmented shots, we decide a movement during sleep. We also try to record all the breath from the beginning of the sleep to the ending of the sleep. In the recorded voice, we extract a part of sleep apnea and a part of heavy panting. Sleep apnea is a phenomenon wherein breath stops from 30 seconds to 1 minute and 30 seconds while sleeping. This phenomenon has been known to kill a person from time to time. This sleep apnea causes abrupt heavy panting after no breathing over a period of time. We expect that our research will pave the road to efficiently and effectively judging sleep apnea without specific equipment.

Keywords: *Bhattacharyya Distance, Sleep Apnea, Breath, Heavy Panting*

1. Introduction

It is said that a person sleeps a third of his or her life, which means that a person sleeps seven or eight hours a day [1]. Since we spend a third of our life in sleeping, sleep is a very import thing to us. We want to know implicit power of various brain activities and sleep during our sleeping. Also, we can make our life energetic and healthy with practicing a good habit for ourselves.

Our contemporaries spend most of our time in sleeping at home. Moreover, people are exposed without protection to various harmful environments when sleeping [2]. So, it is a very important thing to promote sleeping environment with pleasant air.

There are always big differences between individuals from the viewpoint of sleeping hours. Sleeping hours change according to age, gender, season, living environment, job, and so on. Sleep apnea is a negative sleeping symptom, which appears during sleeping with loud snoring. Apnea is a term for suspension of external breathing. During apnea, there is no movement of the muscles of inhalation and the volume of the lungs initially remains unchanged. So, it is a kind of disease that could develop complications related to cardiovascular pulmonary vascular system.

Sleep is composed of two mutually different conditions. The first is Non-Rapid Eye Movement (NREM) slumber and the other is Rapid Eye Movement (REM) slumber [3]. REM sleep, often called "active sleep," is identifiable by its characteristic low-amplitude (small), high-frequency (fast) waves and alpha rhythm, as well as the eye movements for which it is named. Many sleep experts think that

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these eye movements are in some way related to dreams. Typically, when people are awakened from REM sleep, they report that they had been dreaming, often extremely vivid and sometimes bizarre dreams. In contrast, people report dreaming far less frequently when awakened from NREM sleep. Interestingly, during REM sleep muscles in the arms and legs are temporarily paralyzed. This is thought to be a neurological barrier that prevents us from "acting out" our dreams. In Session 2, we research on related works. In Session 3, we consider scene segmentation and voice analysis. And, after some experiment to verify our research in Session 4, we make conclusions in Session 5.

2. Related Work

CCD (Charge-Coupled Device) cameras have been used to ensure the indirect measurement of breathing through the use of image processing of chest x-rays. This method has the advantage of imposing no restrictions on the subject, while it has the disadvantage of low accuracy because there is some difficulty in determining the area where measurements should be made, due to the sleeping subject's motion [4-6].

Measurement system of study, the latest of work, sleep patterns of nursing students to identify and, of subjective Sleep measurement tools and new tools, automation, wireless, sleep tracker. There was a study to review the possibility in nursing and clinical applications [7]. This study, leaning on the basis of the basis of the center grounds related to the surface and ultimately contribute to the Sleep Health Promotion with the aim to try. A research [8] proposed a system to improve sleep disorders with multi-sensing to supplement the causes and diagnosis as well as to measure sleep disorders.

In another research [9], a wireless system test bed is designed to monitor the patients for the signs of sleep apnea. This paper covers the technical aspects of the wireless-based sleep technology for monitoring sleep apnea, which is a sleep disorder that can be detected via continuous monitoring. Some research [10] used a temperature and humidity sensor (SHT11) of H-MOTE2420 sensor and an illumination intensity sensor (GL5507). The research considered a difference-image technique to extract movements from a video in order to detect toss and turn (in bed).

Many attempts to research on sleep apnea have been performed in Korea. Their contents are as follows. To extract the patient sleep apnea, there is a way of recording used to measure the breathing during sleep. This method performs a preprocessing by use of filtering, because of serious noises of data. Also, due to the simplicity of the method, it is very difficult to extract sleep apnea [11]. In making a diagnosis of closed sleep apnea, a most useful and accurate examination is Standard Polysomnography. However, this examination requires complex practice, a lot of manpower and facilities, and many economic burdens [12].

3. Scene Segmentation and Voice Measurement to Measure Sleeping

3.1. Scene Segmentation

In measuring sleep, scene change detection is generally used. In this paper, we use Bhattacharyya distance so as to segment scene. Two patterns that are mutually close in distance in a particular space have almost similar characteristics with big similarity. There are widely used famous methods for distance measurement such as Euclidean Algorithm, DTW (Dynamic Time Warping) Algorithm, Bhattacharyya distance measurement. Euclidean Algorithm is used to look for a real distance. When there are many attribute values for two entities, the similarity degree between two entities is used and the value with high probability is recognized. DTW algorithm is a kind of Pattern Matching Algorithm with non-linear time normalization. For common and uniformly sample intervals, voice patterns are recognized after sampling temporally.

The measurement of the distance used Bhattarcharya Distant measurement that is based on error rate measurement, and it is defined in this equation (1).

$$d^2(i,j) = \frac{1}{2}\sum_{k=1}^{N}\frac{(\mu_{ik}-\mu_{jk})^2}{\sigma_{ik}+\sigma_{jk}} \quad (1)$$

N is the degree of data, μ_{ik} is the average of k times on I, σ_{ik} is the variance of k times on i. The Distance calculation measures the piled up parts in between two Gaussian, and its distance range is from 0 to ∞ showing piling up completely with each Gaussian or not piling at all. The distance measurement is defined in the following Equation (2).

$$B_{dt} = \frac{1}{4}ln\left(\frac{1}{4}\left(\frac{\sigma_p^2}{\sigma_q^2}+\frac{\sigma_p^2}{\sigma_q^2}+2\right)\right)+\frac{1}{4}\left(\frac{(\mu_p-\mu_q)^2}{\sigma_q^2+\sigma_q^2}\right) \quad (2)$$

The σ_p shows variance of p times distribution; μ_p shows average of p times distribution, and p, q shows distribution that is different from each other.

Since the above equation is not used to detect a scene from a video in this paper, the following equation (3) is used. In measuring sleep, the Bhattarcharya distance measurement is used as a method to analyze histogram similarity.

$$d_{Bhattacharyya}(H_1,H_2) = \sqrt{1-\sum\frac{\sqrt{H_1(i),H_2(i)}}{\sqrt{\sum_i H_1(i)\sum_i H_2(i)}}} \quad (3)$$

H_1 expresses the histogram of the present video and H_2 expresses the histogram of the prior video. The i means the number of bins of histograms.

The similarity of two videos increase as the value of Bhattarcharya distance is nearer. At this point, a critical point should be set up for the value of Bhattarcharya distance like equation (4). For more than the critical point, the scene should be segmented. But, for less than the critical point, the scene should not be segmented.

$$d_{Bhattacharyya}(H_1,H_2)\begin{cases}\geq T & Shot \quad Segmantation \\ <T & Leave\ It\ at\ That\end{cases} \quad (4)$$

3.2. Voice Measurement

We can decide whether our sleep is apnea or not by use of recording breathing between 1 hour to 5 hours after sleep. The sleep apnea does not appear just before the sleep or just before the getting-up.

The procedure to decide about sleep apnea is performed like Fig. 1. Snoring during sleeping could be detected on the basis of breathing recording. It is true that there would be no sleep apnea without snoring. Particular attention should be paid in checking whether the breathing stops for long hours. The no-breathing between 30 seconds to 1 minute and 30 seconds has high probability that the person would have sleep apnea. The person would certainly have sleep apnea if he or she suddenly breathes in deeply or sits during sleeping.

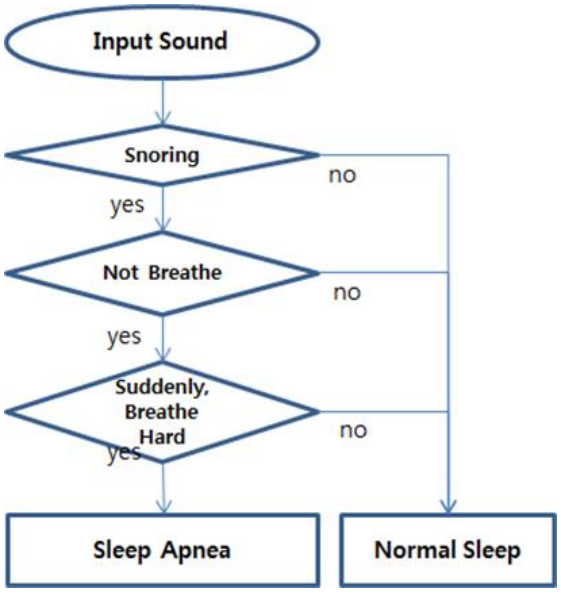

Figure. 1. Decision Flow Chart of Sleep Apnea

We could finally decide the presence sleep apnea after segmenting scene and measuring recorded voice according to Bhattarcharya distance measurement. A characteristic of a sleep-apnea patient is that he or she snores loudly. The combination of video and voice leads us to discern sleep apnea.

In these days, sleep apnea can lead to death at frequent intervals. It is estimated that sleep apnea is increased by fatigue, drinking, insomnia, and so on. Also, it is incurred by complications of a physical defect. So, it is a crucial and serious work to treat sleep apnea.

4. Experiments

For experiments, we used Microsoft Windows 7 as operating systems as Visual Studio 2010 C++ and MySQL for application or data programming. The resolution of video is 1024 x 768. An example of scene segmentation from video is Figure 2. By use of Bhattarcharya distance measurement, scenes are segmented when the critical point is 3,000.

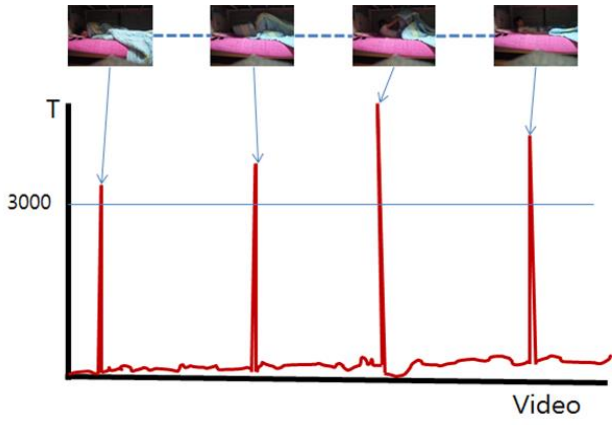

Figure 2. Scene Segmentation from Video

Now, let us check the result of analysis on breath recording. The ware form is analyzed by Sound Forge. The Figure 3 represents the graph of an ordinary person during sleeping. The Figure 4 shows the graph of a person with snoring.

Figure. 3. Ware Form of Ordinary Sleeping

Figure. 4. Ware Form of Sleeping with Snoring

Figure. 5 shows the ware form during snoring. Figure. 6 and 7 show the ware form of sleep apnea.

Figure. 5. Ware Form during Snoring

Figure. 6. Ware Form of Sleep Apnea 1

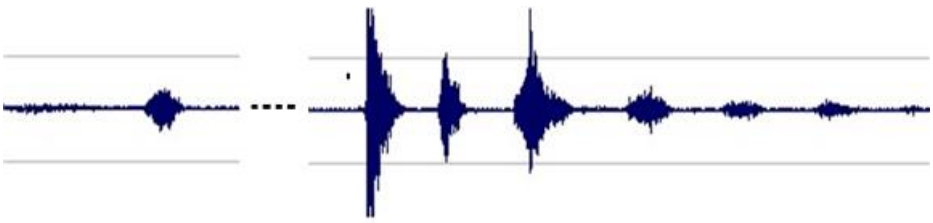

Figure. 7. Ware Form of Sleep Apnea 2

Like what we can see in these Figures, a sleep apnea patient stops breathing for a period of time during snoring. And then, after making a sudden sound, the person breathes short breaths and snores again. We performed experiments for 20 persons during their

sleeping. We got results (Table 1) by use of scene segmentation of Bhattarcharya distance and analysis of breathing recording during sleeping.

Table 1. The Number of Segmented Scenes and Sleep Apnea

Video	The Number of Segmented Scenes	Sleep Apnea
1	23	△
2	15	×
3	22	×
4	33	○
5	25	○
6	17	×
7	19	△
8	9	×
9	15	×
10	12	△
11	31	○
12	23	×
13	27	△
14	16	×
15	18	×
16	17	×
17	9	×
18	11	×
19	22	×
20	19	×
○: Direct Relationship with Sleep Apnea △: Indirect Relationship with Sleep Apnea ×: No Relationship with Sleep Apnea		

Like the above Table 1, we found the fact that a sleep-apnea person or a suspected sleep-apnea person has many scene segments.

5. Conclusion

A person sleeps seven or eight hours a day. That is to say that a person sleeps a third of his or her life. In this paper, we segmented a video into shots with a method by use of Bhattacharyya Distance. And we found that we can decide a movement during sleep after analyzing these segmented shots. We also tried to record all the breath from the beginning of the sleep to the ending of the sleep. In the recorded voice, we extracted a part of sleep apnea and a part of heavy panting. The sleep apnea is a phenomenon that a breath stops from 30 seconds to 1 minute and 30 seconds. This sleep apnea causes abrupt, heavy panting after no breathing over a period of time. We expect that our research would make a road for efficient and effective judgment about sleep apnea without specific equipment.

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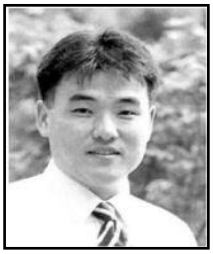

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