

Development of Sleep Disorder Detection System

~ As Part of Development of Clinical Depression Diagnosis Support System for Solitary Person ~

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Abstract. The purpose of this study is development of clinical depression diagnosis support system finally. The Ministry of Health, Labour and Welfare in Japan said number of clinical depression patients was 441 thousand in 1999, was 1.04 million in 2008. Not only it, the number of patients is increasing year by year. Thus, clinical depression can be said national disease. On the other hand, clinical depression is difficult to diagnosis. Because, clinical depression patient will not accept disease. Thereby, clinical depression diagnosis support system is required urgently. Symptoms of clinical depression are psychomotor disorder, sleep disorder, gain/loss in weight and constipation/diarrhea. Moreover, nearly 100% of clinical patients arise sleep disorder. Therefore, in this paper, we propose sleep disorder detection system as part of clinical depression diagnosis support system. In particular, a sheet type pressure sensor is installed on bed. Next, body pressure is obtained by a sleeper as examinee on pressure sensor. Thereby, the body pressure shows movement in sleeping (wake-up in night, hypersomnia and insomnia). We can catch a condition in sleeping and difference of usual/unusual by using body pressure values.

Keywords: Sleep disorder, detection system, clinical depression, diagnosis support system.

1. INTRODUCTION

The Japanese Ministry of Health, Labour and Welfare surveys many kinds of patients every 3 years. Results of survey are collected into “Patients Survey” (Ministry of Health, Labour and Welfare (2014)). Figure 1 shows the number of mood disorder patients in 1996 to 2014. The “Patient Survey” says patient number of mood disorder represented by clinical depression was 433 thousand in 1996. Then, the number increased by 258% in 18 years. In particular, the number increased in early 21st century drastically. Therefore, it is no exaggeration to say that mood disorder is the Japanese national

disease. Moreover, the number will increase year by year. On the other hand, number of severely clinical depression patient who needs special care is not many. About 90% patients have mild to middle clinical depression.

It is important to notice difference from usual behavior for detection and remedy of clinical depression. However, it is difficult to notice solitary person's strange or different behavior from other people. Moreover, clinical depression patients think often that cause of bad physical condition is physical illness or lacking an ability. Hence, untreated clinical depression patients hesitate to go to hospital and do not attempt to recognize mental problem. Furthermore, if mild clinical

depression is not treated, it becomes severe. It is important to be treated early.

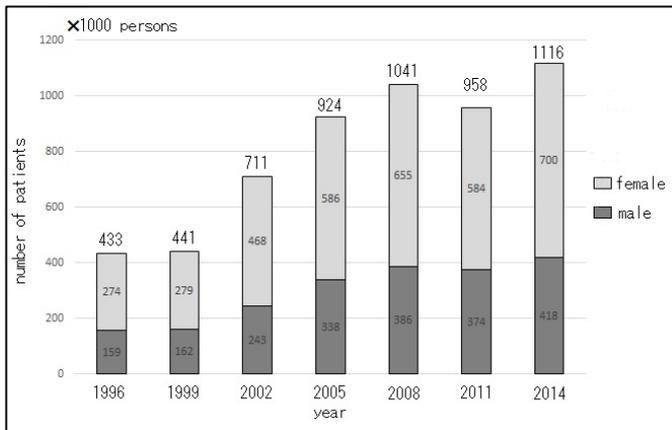


Figure 1: The number of mood disorder patients.

Recently, there are many researches, treatment methods and diagnostic methods for clinical depression (Hayashi (2011)) (Tanaka *et al.* (2011)) (Kudo *et al.* (2011)). There are many kinds of symptoms in clinical depression. In particular, mild clinical depression patients have sleep disorder almost 100%. In addition, 90% of patients who have sleep disorder have fatigue, malaise, anorexia and headache. Furthermore, 50% to 90% of patients have anorexia. 40% to 70% of patients have gain/loss weight and constipation/diarrhea. Table 1 shows symptoms in mild clinical depression, and table 2 shows complications in sleep disorder. Moreover, there are many symptoms as threat in daily life which impossible to answer the phone, impossible to concentrate, impossible to work, self-hate, be nervous and get antsy.

Against that background, we developed indoor behaviors identification system using pressure distribution sensors as detecting clinical depression system (Tajima *et al.* (2012)). This system for solitary person can identify going-out, return-home, in-bathroom, out-bathroom, in-lavatory, out-lavatory and cooking as daily behaviors. The system can identify each behavior in 94.9%. Moreover, the system records behavior pattern, number of times of action and behavior time. If the person does not act or the system identifies strange behavior pattern, the system warns as abnormal condition. Altogether, this system is a part of clinical depression diagnosis support system for solitary person. However, this system alone may not diagnose correctly. Therefore, some systems which are useful for diagnosis should be used in combination. Accordingly, in this paper, we propose sleep disorder detection system. In addition, the purpose of this study is development of clinical depression diagnosis support system finally.

Table 1: Symptom in mild clinical depression.

symptom	proportion
sleep disorder	100%
anorexia	50% ~ 90%
gain/loss weight	40% ~ 70%
constipation/diarrhea	40% ~ 70%

Table 2: Complications in sleep disorder

complication	proportion
fatigue, malaise	90%
anorexia	90%
headache	90%

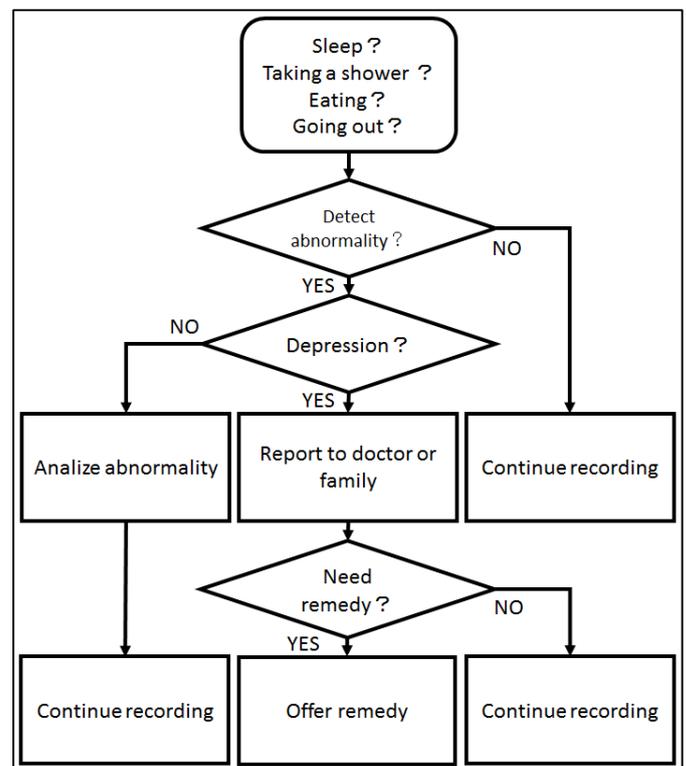


Figure 2: System function and usage flow.

2. WHOLE ASPECT OF STUDY

In this study, the target is solitary person who can not be watched by other people in daily life. We develop a system which can warn as abnormality, if the system detects characteristic actions and conditions which are seen in clinical depression patients. Our clinical depression diagnosis support system will have functions which sleep disorder detection using sheet type pressure distribution sensor, eating

disorder detection using odor sensor, impaired psychomotor performance detection using mat type pressure distribution sensor, abnormal weight gain/loss detection, taking a shower detection using humidity sensor and over/under action quantity detection using CO2 sensor. Moreover, all obtained data collect to database. Finally, all functions and sensors will be used in combination online. Figure 2 shows system function and usage flow.

Next to indoor behaviors identification system, we propose sleep disorder detection system as second step of clinical depression diagnosis support system. The reason of choice of sleep disorder detection system is that sleep disorder appear in almost mild clinical depression patients (refer to table 1). Therefore, sleep disorder is one of the strongest feature for clinical depression. Moreover, we think that detecting sleep disorder becomes basic criterion of clinical depression.

3. SLEEP DISORDER DETECTION

In this section, we explain about function, sensor and method of sleep disorder detection.

3.1 Function

In general, healthy persons can sleep in 10min to 15min. In addition, this time is called “sleep latency”. If the system detects unusually long sleep latency, the system identifies this phenomenon as sleep disorder. Moreover, the system can detect frequent awakening in night, sleep in day time and plethoric sleep. Each condition is evaluated as sleep disorder.

Despite user is already awake, user does not have energy to get out of bed. In this situation, the system detects impaired psychomotor performance. This function is auxiliary function for this system.

3.2 Sensor

For detection of sleep disorder, we adopt fabric sheet type pressure distribution sensor that is named “Boditrak” (Vista Medical Ltd. (2016)). This sensor is developed by “Vista Medical Ltd.” for medical use. Main utilization is prevention of bed sore. The features of this sensor are flexible, stretchable and durable. Additionally, it has air and vapor permeable. Moreover, it has 3 layers. The layer 1 is alternating knit conductive and non-conductive columns. The layer 2 is pressure sensitive fabric that varies resistance with force. The layer 3 is alternating knit conductive and non-conductive rows.

Table 3 shows sensor size and specifications. Figure 3 shows visual aspect of sensor. Moreover, Arrows and circles

Table 3: Sensor size and specification.

sensor size (mm)	2032×863
sensing area (mm)	1854×762
number of sensing point	64×27= 1728
sensing point size (mm)	25.4×25.4
sensor pitch (mm)	3.6×2.93
maximum sensing period (Hz)	50
thickness (mm)	2.5

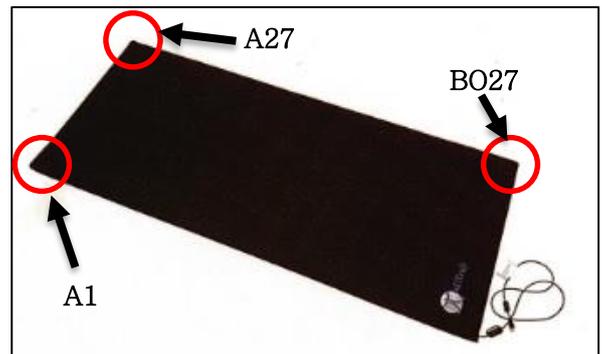


Figure 3: Sensing point coordinates (Vista Medical Ltd. (2016)).

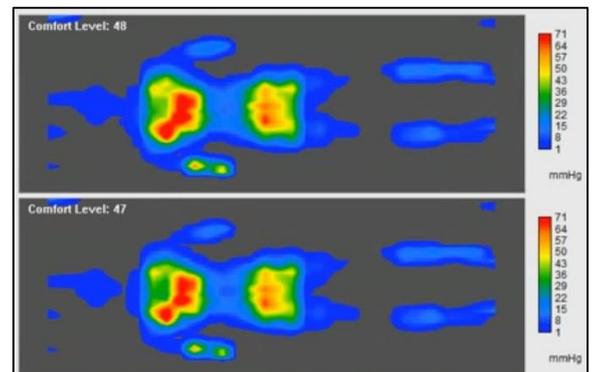


Figure 4: Example of sleeping body pressure data (Vista Medical Ltd. (2016)).

show sensing point coordinates. This sensor works with general computer that has USB. The sensor can work with only USB power supply. Thereby, it does not need external power supply. The Coordinates numbers are “A1” to “BO27”. Thus, there are 1728 sensing points. “BO” in figure 3 means 64 (“A”, “B” ,,, “Y”, “Z”, “AA”, “AB” ,,, “BN”, “BO”). This sensor is developed for using on bed. Figure 4 shows that user lie on one’s back. In figure 4, around scapula and breech are pressured strongly. This sensor gets numeric pressure value by unit of mmHg. In this system does not use camera and video image that can identify individual. Clinical depression patients

feel stress easily. Moreover, the stress aggravates clinical depression. Therefore, system which gives any stress should not be used. This sensor can hide under bed sheet. Furthermore, thickness is very thin (2.5 mm). Thus, the sensor does not give any discomfort and stress to slept user.

Only in experiments, we use infrared camera that can take in night or lightless environments. This reason is that we need to compare obtained data from pressure distribution sensor with actual slept person's conditions. Understandably, infrared camera is not used for actual users of this system. The infrared camera can synchronize with pressure distribution sensor. A function of synchronization is installed in control software of pressure distribution sensor that is named "FSA". Thereby, we can check all obtained data from pressure distribution sensor. This infrared camera can work only USB power supply.

3.3 Method

This sensor is put on bed mattress. Then, bed sheet is put on this sensor. Thus, the sensor is hidden by bed sheet. The sensor gets body pressure as figure 4. Sampling period is 30 second. Therefore, the sensor gets 2 data in a minute. This sampling period is decided for consideration of data size. Moreover, high resolution data is not needed in this method, because slept condition is not active. Table 4 shows example of obtained data. The data has 2 coordinates as lengthwise and crosswise. Lengthwise is named "A" to "BO". Crosswise is numbered 1 to 27. Lengthwise and crosswise shows coordinates that are combined as "BO27". "Frame No." in table 4 shows number of obtained data. According to sampling period of 30 second, "Frame No." 3 means after 1.5 minute from starting sensing. Additionally, maximum "Frame No." is not set. The maximum "Frame No." is depended on HDD capacity.

We make feature value data from obtained data which are coordinates of COP (Center of Pressure), movement distance of COP, movement speed of COP, movement angle of COP, acceleration of COP, movement frequency of COP, maximum pressure value, minimum pressure value, pressed area and pressed part of body. Moreover, we will adapt statistics and AI techniques (e.g. discriminant analysis, support vector machine, deep learning) as identification and detection method for clinical depression.

In this experiment, the bed width is 690 mm, length is 2110 mm, height is 320 mm. This bed size is called "Single" in Japan. One reasons of choose the bed size is that there is no common or prescript bed size in Japanese hospitals. Hospital's bed must be made for patients. Therefore, we think hospital's bed is the best for clinical depression patients. For this reason, we use "Single" bed in this experiment that is the commonest use for people who living alone. Moreover, our target people (the examinees of this experiments and the users of this system) are adults.

Table 4: Example of obtained data

Frame No.	1	2	3
A1	42.66	60.05	91.70
A2	82.14	26.41	28.82
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BO26	24.49	65.79	98.89
BO27	98.86	97.10	0.77

## 4. CONCLUSIONS

In this paper, we propose whole system functions, usable sensor and feature values for sleep disorder detection system as a part of clinical depression diagnosis support system. We are going to verify proposed method by some experiments as future task.

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