

# Exploring Individual Care Plan for a Good Sleep

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## Abstract

This paper focuses on care plans (i.e., rough schedules) in care houses and evaluates them from the viewpoint of a deep and stable sleep which contributes to provide comfortable and healthy life for aged persons. For this purpose, this paper investigates the care plans which are basically based on the current care plans but change a small part of a schedule as an aged person desires. Through the human subject experiments in the actual care house, the following implications have been revealed: (1) the proposed care plan decreases the time of the light sleep; and (2) the proposed care plan provides the deep sleep (i.e., 9 years younger sleep in our experiment).

## Introduction

Recently, a lot of aged persons who cannot live without someone's helps are cared in care houses, and they desire to have a comfortable and healthy life. However, such comfortable and healthy life is difficult to be maintained in the care house because the schedule such as the meal, exercise or rehabilitation, and sleep time are mostly fixed and the same among all persons from the viewpoint of an efficient support for aged persons. From this situation, the *care plan* (i.e., a rough schedule) that considers the life-cycle of each aged person is highly demanded. We call such a care plan as an *individual* care plan.

To provide the comfortable and healthy life for aged persons as the first steps towards our goal, this paper focuses on the *sleep stage* to evaluate whether the care plan is appropriate from the viewpoint of good sleep. This is because the physical condition of aged persons is mostly good when they take the *deep* and *stable* sleep, while the condition is mostly bad when they take the *light* and *unstable* sleep. Since our previous method succeeded to estimate the sleep stage without connecting any devices to human's body through an adaptation to each person [6], we employ this sleep stage estimation method in the actual care house. This method, in particular, calculates the sleep stage from the heartbeat data measured by the pneumatic approach using the air mattress in a bed.

This paper is organized as follows. The next section explains the care plan and its problem, and the following section evaluates the care plan from the viewpoint of the sleep stage. Then, the experiments are conducted, the experimental results are discussed, and the conclusion is finally given in the last section.

## Care Plan

### Tradeoff between desires of care workers and aged persons

Fig. 1 (a) shows a tradeoff relationship of desires of care workers and aged persons, where the vertical and horizontal axes respectively indicate desire degree of care workers and aged persons. Concretely, the care plans that care workers desire (i.e., the same and fixed schedule plan) are not comfortable for aged persons (which area is shown in the left-up blue oval). For example, the aged persons should go to bed and wake up at the pre-determined time, which is the same in all aged persons. On the other hand, the care plans that aged persons desire (i.e., the individual and flexible schedule plan) are not applicable for care workers to support aged persons (which area is shown in the right-down blue oval). For example, care workers limit to care aged persons when aged persons want to eat their meals in their desire time (i.e., the different time).

To tackle this tradeoff relationship between desires of care workers and aged person, we explore the care plans as shown in Fig. 1 (b), which are basically based on the current care plans (i.e., the same and fixed schedule plan) but change a small part of a schedule as an aged persons desires (which area is shown in the right-side of the current care plans with the light purple color). We expect such care plans because (1) they are mostly the same as the current care plans, which can be executed as usual, but (2) they include a part of requests of aged persons, which can contribute to providing a good sleep to aged persons.

In order to find such care plans shown in the light purple area, we employ our previous method [4] that can explore the specific area in multi-objective optimization problems.

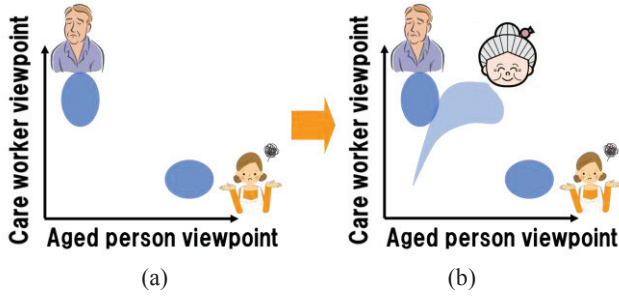


Fig 1. Tradeoff relationship between desires of care worker and aged persons

### Scoring activities in care plans

In order to plot the several care plans in the 2D map shown in Fig 1, the score of the activities in care plans should be calculated. Such activities are composed of the followings events: (i) meal (breakfast, lunch, and dinner) including liquid, (ii) snack (between breakfast and lunch, between lunch and dinner) including liquid, (iii) wake up time and bedtime, (iv) exercise or rehabilitation, (v) bath, (vi) gardening, (vii) reading newspapers, and (viii) others. The vertical and horizontal value of care plans in the 2D map is determined as follows, where  $n$  indicates the total number of activities and  $activity (i)$  indicates the  $i$ -th activity shown in above:

$$y = \sum_{i=1}^n \text{score of activity } (i) \text{ of care worker}$$

$$x = \sum_{i=1}^n \text{score of activity } (i) \text{ of aged person}$$

Each score of activity of care worker and aged person is determined as follows. When focusing on dinner, for example, the care workers want to have aged persons eat all dinner. From this request, the score (ranged from 0 to 100) of the care workers is set to 0 score when the aged person eat nothing, a little amount of a meal, or less than a middle amount of a meal, 20 score when eating a middle amount of a meal, 50 score when eating less than a proper amount of a meal, 100 score when eating a proper amount of a meal, and 0 score when eating more than a proper amount of a meal as shown in Fig 2 (a). The score (ranged from 0 to 100) of the aged person, on the other hand, is set to 100 score when eating more than a proper amount of a meal and is set to less values when eating less than a proper amount of a meal in the case of the aged person who wants to eat to more than a proper amount of a meal.

When focusing on water as the another example as shown in Fig 2 (b), the care workers does not want to allow aged persons to drink more than 1000cc because the aged person is limited to drink due to a diabetes, which sets the 100 score of care workers when the age person drink

around 1000cc (*i.e.*, a proper amount), 50 score when drinking around 750cc or 1250cc, and 0 score when drinking less than 500cc or more than 1500cc. The score of the aged person who wants to drink a lot in comparison with other persons, on the other hand, is set to 100 score when drinking around 1500cc (which is quite larger than a proper amount of liquid), 50 score when drinking around 1250cc or 1750cc, and 20 score when drinking around 1000cc, and 0 score when drinking less than 750cc

		Care worker	Aged person
<b>Dinner</b>	nothing	0	0
	a little	0	0
	⋮	0	0
	middle	20	0
	⋮	50	50
	proper	100	70
	over	0	100

(a)

		Care worker	Aged person
<b>Water</b>	200	0	0
	500	0	0
	750	50	0
	1000	100	20
	1250	50	50
	1500	0	100
	1750	0	50

(b)

Fig 2. Score of activities in care plans

These scores are determined via an interview with care workers in care house. Note that the scores of the care works can be easily determined by talking with them, while those of the aged persons is hardly to be determined because some persons do not want tell their preference or dementia patients are difficult to properly answer the questions on their preference. From such a difficulty, the scores of aged persons are determined by care workers who care them (*i.e.*, the score of an aged person A is determined by a care worker who cares an aged person A).

### Evaluation of care plan

#### Sleep stage

To evaluate care plans, we employ the sleep stage as shown in Fig. 3. In this figure, the horizontal axis indicates the sleep time in a bed, while the vertical axis indicates the sleep stage divided into six stages, *i.e.*, the wake-up stage, REM sleep stage, stages 1, 2, 3, and 4 represented by W, R, 1, 2, 3, and 4, respectively. Note that the stage 4, in particular, indicates the deepest sleep stage. Since the current care plan which is common for all aged persons

may not be effective for a certain person, such a person sleeps as shown in Fig. 3 (b). However, he has a chance to sleep as shown in Fig. 3 (a) if the care plan is specialized for him. This indicates that the area of the sleep stage (represented by the orange area) becomes large and the change of the sleep stage does not often occur when aged persons take the deep and stable sleep as shown in Fig. 3 (a), while its area becomes small and its change often occurs when they take the light and unstable sleep as shown in Fig. 3 (b).

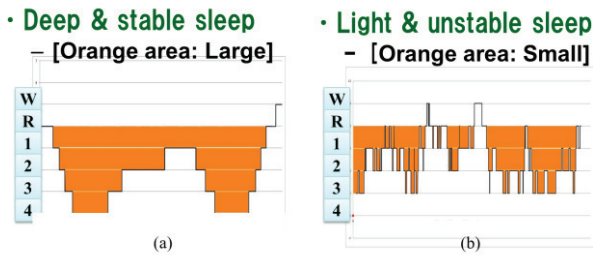


Fig 3. Sleep stage

By focusing on such differences, the care plans are evaluated from the following criteria, which indicate that aged persons have a deep and stable sleep when the total time of the sleep stages 3 and 4 is large, while they have a light and unstable sleep when the total time of the wake and REM sleep stages is large.

- **Degree of deep sleep:** Total time of the sleep stages 3 and 4
- **Degree of light sleep:** Total time of the wake and REM sleep stages

### Sleep stage estimation

To acquire the sleep stage, the major conventional approach [2] measures the brain wave of humans by directly connecting the devices to their heads, which method is proposed by Rechtschaffen and Kales for the medical purpose. However, this system is not realistic for the aged persons in the care house due to the direct connection of devices to their heads. In particular, such connections prevent from the deep and stable sleep of the aged persons by restricting their behaviors.

To overcome this problem, Watanabe proposed the sleep stage estimation method without connecting any devices to human's body, *i.e.*, he succeeded to estimate sleep stage from the heartbeat data measured by the pneumatic approach using the air mattress in a bed [7]. His method is based on the results of the several articles suggested that the heartbeat has the strong relation to the sleep stage [1, 3, 5]. However, this method is developed according to the actual data of the *young* human subjects, which may not be

effective in *aged* persons. Note that the ratio of sleep stage (*i.e.*, the wake-up stage, REM sleep stage, stages 1, 2, 3, and 4) changes as age increases.

To tackle this problem, our previous research proposed the novel method that can estimate the sleep stage without connecting any devices to human's body through an adaptation to each person [6], and showed that the accuracy of the sleep stage in our method is better than that in Watanabe's method [7]. Since the sleep stage in our method is modified to adapt to each person, we do not have to matter whether young or aged person.

### Implementation

Since our method estimates the sleep stage according to the heartbeat data measured by the pneumatic approach as the same as Watanabe's method, *Emfit* sensor which is set under the bed is employed as shown in Fig. 4 (b). Note that the heartbeat data can be obtained from *Emfit* sensor by just laying on the bed, which means that the data can be measured without connecting any devices to the human body. *Emfit* sensor is developed by VTT Technical Research Center of Finland for care support in the 1990's.

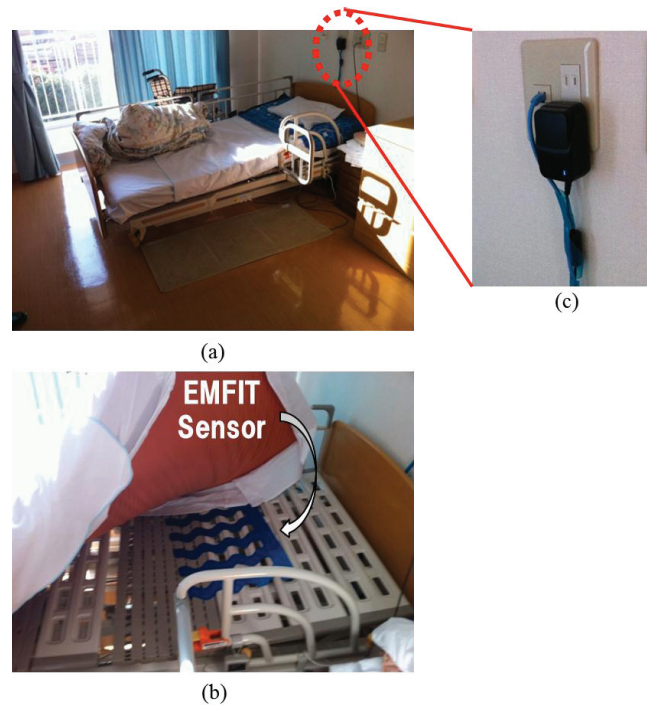


Fig 4. Emfit sensor under the bed in care house

To evaluate the care plans in the actual care house, we set up our method with *Emfit* sensor. Since *Emfit* sensor is set under the bed as shown in Fig 4 (b), the bed is usual as shown in Fig 4 (a), except for the AC adapter for battery of *Emfit* sensor and the Ethernet cable for transmitting the

heartbeat data to the server PC where our method is installed as shown in Fig 4 (c). From this setting, the aged persons can stay their rooms as usual.

## Experiment

### Cases

As preliminary experiment toward appropriate care plans, we conduct the human subject experiments in the actual care house, and compare the deepness of the sleep in the current care plan with the deepness of the sleep in the individual care plan that our method finds (hereafter, we call it the proposed care plan). The human subjects include the 82 aged diabetes person, 89 aged dementia and emotional illness person, and 107 aged healthy person.

### Experimental result

Fig. 5 shows the experimental result, where the vertical and horizontal axes indicate a desire degree of the care workers and aged persons, respectively. In detail, the red and blue circles indicate the current and proposed care plan, respectively. The circles indicate the results of one aged person in one month (*i.e.*, 30 days), which means that 30 circles are plotted in Fig.5 but some are overlapped. Note that the tendency of the results is mostly the same in other aged persons.

From this figure, we can find that the area of the current care plan and that of the propose care plan is mostly separated. This indicates that the current care plan takes the care workers viewpoint more important that the proposed care plan, which can be understood that the area where the area of the current care plan is located in the left side in comparison with that of the propose care plan.

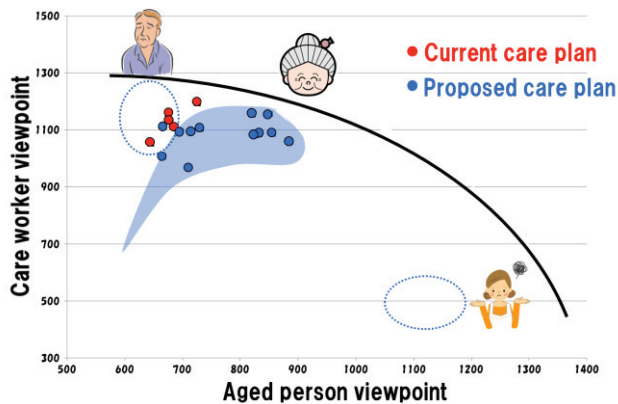


Fig 5. Experimental result

## Discussion

Fig. 6 shows the deepness of the sleep, where the vertical and horizontal axes indicate the total time of the sleep stages and care plans, respectively. In detail, the vertical axis in Fig. 6 (a) indicates the total time of the wake and REM sleep stages which cover the light and unstable sleep, while the vertical axis in Fig. 6 (b) indicates the total time of the sleep stages 3 and 4 which covers the deep and stable sleep. In this figure, the red and blue bars indicate the current and proposed care plans, respectively.

From Fig. 6 (a), the time of the light and unstable sleep in the proposed care plans is shorter than that in the current care plans, which contributes to decrease a frequency of wandering in midnight. From Fig. 6 (b), on the other hand, the time of the deep and stable sleep in the proposed care plans is larger than that in the current care plans, which contributes to provide a better sleep than usual. What should be noted here is that the proposed care plans can provide 9 years younger sleep in this experiment.

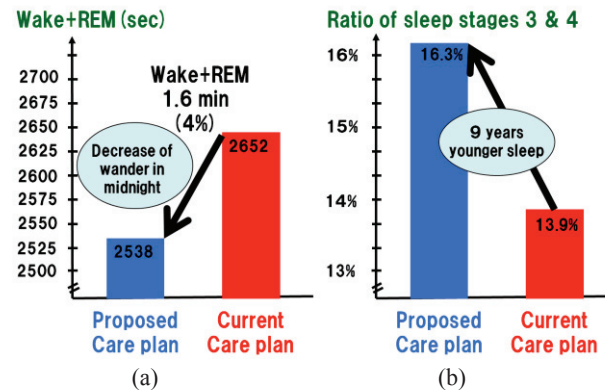


Fig 6. Deepness of sleep and care plans

## Conclusion

This paper focused on a sleep to provide a comfortable and healthy life for aged persons and explored the individual care plans that can provide a *deep* and *stable* sleep. For this purpose, we investigated the care plans which are basically based on the current care plans but change a small part of a schedule as an aged person desires. Through the human subject experiments in the actual care house, the following implications have been revealed: (1) the proposed care plan decreases the time of the light sleep; and (2) the proposed care plan provides the deep sleep (*i.e.*, 9 years younger sleep in our experiment).

Since this project is ongoing, a lot of issues including further careful qualifications and justifications should be tackled. Examples include (1) an estimation of score of the aged person instead of an interview from the care workers, (2) an extraction of the activities of deriving a deep and



stable sleep which is scheduled in the care plan, and (3) generality of the obtained implications by increasing the number of aged persons.

### Acknowledgement

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