

치매환자를 위한 대화 보조 시스템

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Communication Aid System For Dementia Patients

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요약 : 본 연구는 치매노인 환자와 간호사들의 생활의 질의 향상에 목표를 둔다. 이를 위해 치매환자를 위한 대화보조 시스템이 제안되었고, 이 시스템은 주로 세가지 모듈, 즉, 음성인식엔진, 화상 에이전트, 간호 스케줄에 의해 구분된 대화 데이터베이스 등으로 구성되었다. 남성 치매 환자에 시스템을 도입함에 의해서 간호시설의 실제적인 환경에서 시스템의 평가가 이루어졌고 시스템이 도입되었을 때와 되지 않았을 때의 비교연구도 실시하였다. 치료 전문가(occupational therapist)들이 비디오 촬영을 통해서 대상자의 반응을 평가한 결과, 치매환자의 요구를 충족시키는데 있어서 대화 시스템이 전문간호사들보다 더 응답적이었다는 것을 보여준다. 게다가, 시스템을 도입함에 의해서 대상자의 발화를 유도하는 빈도가 증가함을 알 수 있었다.

Abstract : The goal of the present research is to improve the quality of life of both the elderly patients with dementia and their caregivers. For this purpose, we developed a communication aid system that is consisted of three modules such as speech recognition engine, graphical agent, and database classified by a nursing schedule. The system was evaluated in an actual environment of nursing facility by introducing the system to an older male patient with dementia. The comparison study was then carried out with and without system, respectively. The occupational therapists then evaluated subject's reaction to the system by photographing his behaviors. The evaluation results revealed that the proposed system was more responsive in catering to needs of subject than professional caregivers. Moreover, we could see that the frequency of causing the utterances of subject increased by introducing the system.

Key words : Dialog System, Speech recognition, Dementia, Caregiver, Virtual conversation

INTRODUCTION

Recently, as an aging population has grown in developed and developing countries, the quality of life(QOL) of the elderly has become more and more important issue. Therefore, the QOL related technologies and secure environments have been designed for independent living and social participation of the elderly. In particular, the present study focuses on the QOL of the elderly with dementia [1, 2, 3, 4]. In the viewpoint of their rehabilitations, it is important for them to maintain their mental peaces. For

one of the methods keeping or recovering their emotional comfort, the interaction based on a free conversation can be taken into account in this study. However, the communication with dementia patients should not be treated equally with normal people, because of the degenerative symptom of dementia that influences general linguistic knowledge and skill. Our approach aims to improve QOL of the elderly with dementia as well as caregivers by providing conversation partner available whenever the dementia patients want. In general, dementia patients have a tendency of repeatedly talking about

the same subjects in communication owing to the loss of memory and cognitive function. Particularly, this might cause a mental stress or burden to family caregivers in the course of long-term care[5,6]. Therefore, they usually use a social support system such as the day-care centers or the skilled nursing facilities. In the case, professional caregivers or occupational therapists can provide advice, support, and help to assist family caregivers.

On the basis of those backgrounds, therefore, we developed the communication aid system[7,8,9,10] as a good conversation partner for dementia patients. The system is focused on a natural interaction with the elderly with dementia through spontaneous speech, without any constraints in behavior and usage. The system is realized by integrating several functions, namely speech recognition, generation of agreeable responses, time-sorted dialog acquisition, and graphical interface with an image of virtual caregiver. For evaluation, we examined the demand and reaction frequencies of subject to the proposed system and the professional caregivers, respectively, while shooting behaviors of patient with a video camera. Besides, the contents of conversation were also examined by analyzing the contents of videotapes.

Overview of communication aid System

1. Primary Functions of System

In order to realize more natural interaction between dementia patient and communication aid system, system is required to equip with necessary functions as following.

The techniques of isolated word recognition were used for speech interaction, which would be more relevant to

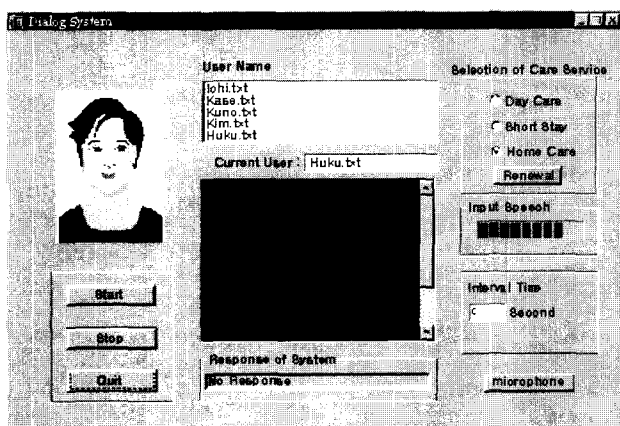


Fig. 1. Communication aid system with speech recognition candidate list, care service selection, and graphical user interface as a main frame

the limited and repeated utterance patterns of the elderly with dementia

System makes responses by both recorded voices and the synchronized graphical user interface.

System makes agreeable responses by chiming with a user for a smooth and natural interaction.

System memorizes the time of capturing incoming speech signals for searching dialog database classified by time schedule at nursing facility.

System makes the same response as the previous one when a user asks back within a preset time, since dementia user has a tendency to reconfirm the answers at a frequent rate.

System has adaptability to different environments such as the care service of nursing facility or home-care.

System has a general-purpose for users with different dementia symptoms.

Figure 1 shows the main frame of communication aid system with recognition candidate list, care service selection, and graphical face image of virtual caregiver as main functions.

Although system depends on techniques of speech recognition as an interaction method with user, the performance of speech recognition might be sometimes degraded because of the ambient noisy environments or unclear utterances mixed with dialects for the aged user with dementia. Therefore, the supplementary functions of speech recognition were adopted for a maintenance of natural interaction. The first one is a usage of dialog database sorted by the timetable of nursing home, in which system can inform user of necessary information on time schedule of day-care service. The other one is to make agreeable responses by chiming with user. Consequently, system can keep smooth virtual conversation even when it fails in recognizing input speech correctly, or when incoming voices turn out to be not registered in recognition candidate list. As a result, user might regard system as a friendly partner, just like familiar caregivers or family members.

2. Mechanism of System

The communication aid system manages several functions mentioned above in a real-time processing. Figure 2 shows the operating mechanism of interactive processing between system and user with dementia.

The interaction manager controls the three kinds of major modules such as speech recognition engine[3,4], graphical agent, or database classified by nursing service

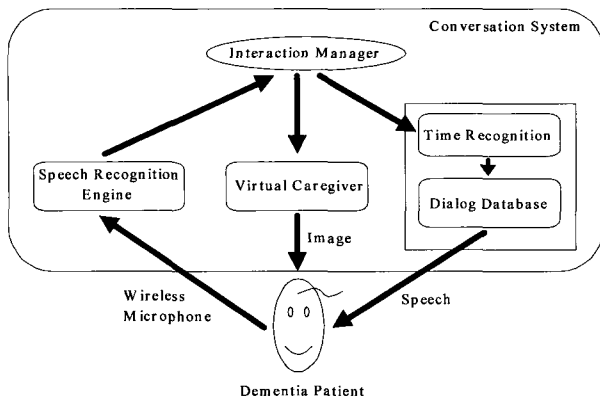


Fig. 2. Procedure of interactive processing between system and dementia user

schedule. When user utters, the input speech signals are first captured by speech recognition engine module. The recognized results are then given to the interaction manager that captures the present time of acquiring input signals, to select the most likely and suitable reply out of database at the time interval. It then makes a response with recorded voices, simultaneously synchronizing them with a lip of virtual caregiver image. In this case, the function of detecting input signals is suspended during the response of system for the prevention of oversensitive response to input signals, and then ready for detecting the next input speech. Moreover, system is designed to make the same response again if the input voices are captured within an arbitrary preset time.

PRELIMINARY INVESTIGATION

1. Behavioral Patterns of Dementia Patient

For an effective design of communication aid system, the behavioral patterns of dementia patient were first examined at nursing facility. The subject was 72 years male patient with vascular dementia. He has received day-care service at nursing home, which is performed from 8:30 a.m. to 3:30 p.m. on weekdays. For this study, the official approval was obtained from the ethics committee of nursing facility and from his family members as well.

Figure 3 shows the observation results examined for 90 minutes(from 2:00 p.m. to 3:30 p.m.) of each day-care service during 3 days. It presents average frequencies in each different behavioral pattern such as complaint, knocking on a door, or wandering.

It was found that subject had the most frequent behavioral pattern in complaint among three kinds of the

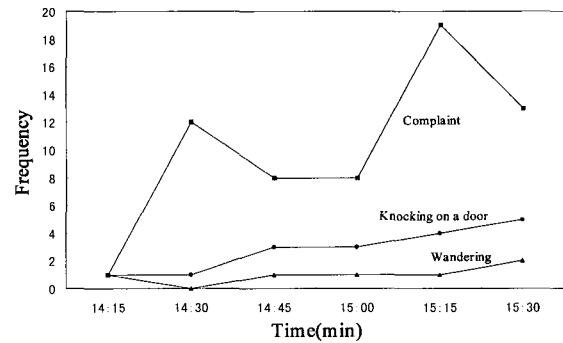


Fig. 3. Average frequencies of behavioral patterns such as complaint, knocking on a door, or wandering

patterns, because he increasingly complains and demands to allow him to go back home. Generally, dementia patients are very sensitive to different environments from their home, so that the changes in resident environment or life schedule can cause disappointment, frustration, or fear. In case of subject, therefore, it seems that an agitation or uncomfortable emotional state persists and grows worse over time. Moreover, since dementia has a disorder of memory, subject affected by it occasionally develops depression or mental instability. On the basis of this investigation, consequently, it turned out that system should be designed to be a conversation partner as a good listener, sometimes leading him to talk, so that it might help him to be restored to a comfortable emotional state.

2. Dialog Database for Dementia Patient

From the investigation as mentioned above, we sorted out utterance types of subject as analysis data for building the most relevant and suitable dialog database. The elderly with dementia often finds it hard to remember the meaning of words that normal people usually use, or to think of words that they want to say. In this study, therefore, we adopted several dialog patterns concerning how to talk to dementia patients according to the following criteria[2] through the professional knowledge and experiences of both caregivers and occupational therapists.

System should be designed to use the dialog that does not make agitation or frustration worse for the elderly with dementia.

System tries to call by name or intimate nickname.

System has to speak slowly and distinctly and try to use familiar words and short sentences, occasionally mixed with regional dialects.

System always keeps things positive, for example, trying to offer positive choices like "let's take a rest until your family come here", or "please wait a minute, your

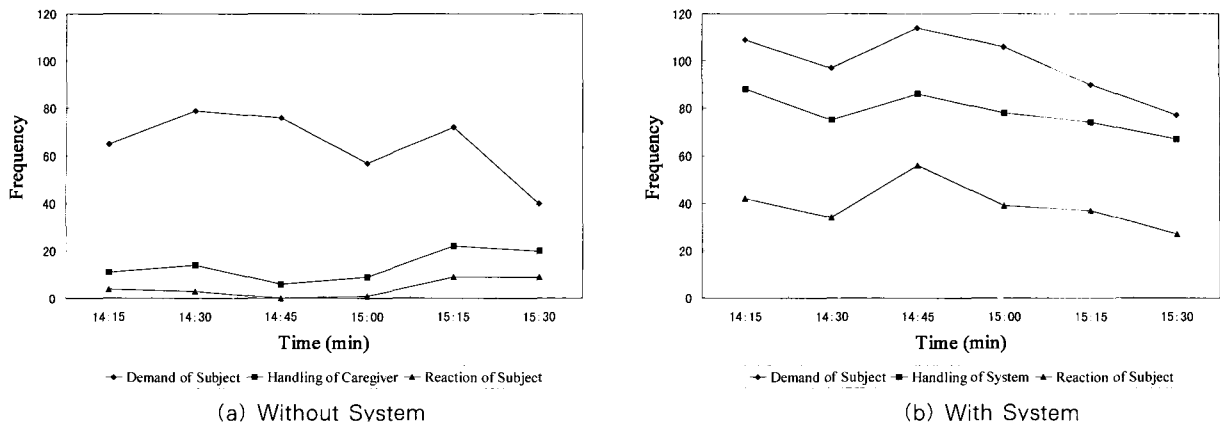


Fig. 4. Frequency comparison. (a) The frequencies of demand of subject, response of caregivers, and reaction of subject when system was not given. (b) The frequencies of demand of subject, response of system, and reaction of subject when system was given

favorite desert would be served after lunch.”

System should ask simple questions as possible as it can, which can be answered with yes, no or one-word answer when it is difficult to know what patient wants.

On the basis of these criteria, we collected several kinds of speech corpus from two female professional caregivers for responses of system, whose voices particularly turned out to be more responsive for subject than others. Besides, we took care to consider all possible situations, which might happen at nursing home, as well as changes of necessary information or schedules.

EXPERIMENTS AND DISCUSSION

1. Experiments

In experiments, system was set at nursing facility after lunch when subject was in the most uncomfortable emotional state. For more natural interaction, the recorded speech of caregivers was used instead of synthesized one that had been proved not to be so much responsive to him. The operating experiments were performed in a relatively noisy environment of the main hall where nursing home residents have rests or meals. For means of interaction, the small size of wireless microphone (WT-1110, TOA, Japan) was used for free behavior of subject.

For evaluation, the comparison study was carried out, one of which was performed for 90 minutes after lunch in each day during 5 days when system was given. In this case, the nursing services of caregivers were restricted while introducing system. The other was performed without system under the same condition. In this case, caregivers

were allowed to do nursing activities whenever needed. Each experimental evaluation was conducted every second day when occupational therapists observed his reactions to each response of both system and caregivers, respectively, photographing his behaviors using video camera.

2. Evaluation Results

We performed the comparative study with and without system, respectively. Figure 4 shows accumulated frequencies of three kinds of components when system was given or not, respectively. In the figure, (a) indicates the case with response of caregivers to demands of subject, where there are three different components such as demand of subject, response of caregivers, and the corresponding reaction of subject. On the other hand, (b) indicates the case with response of system instead of caregivers to demands of subject, where there are also three components such as demand of subject, response of system, and the corresponding reaction of subject.

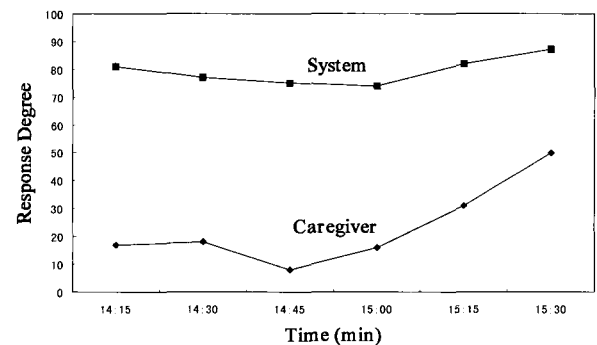


Fig. 5. Comparison of the response degrees between caregivers and system to demands of subject

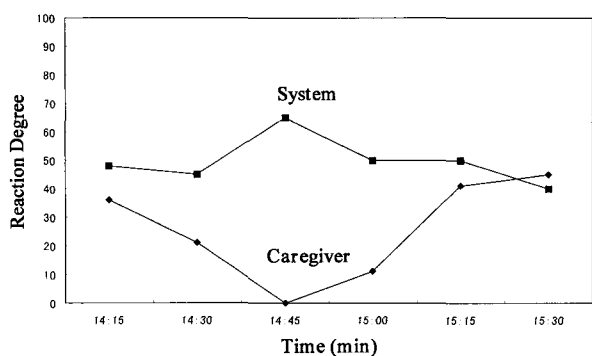


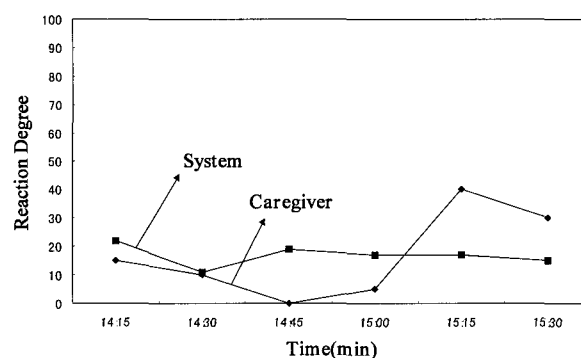
Fig. 6. Comparison of subject's reaction degrees to each response of both caregivers and system

From the results mentioned above, we induced two different response degrees for a quantitative evaluation, one of which gave a ratio of demand of subject to response of caregivers. The other was a ratio to response of system. Figure 5 shows a comparison of response degrees between caregivers and system in terms of response frequency to demands of subject. It was found that system was more responsive to demands of subject than caregivers of busy nursing schedules.

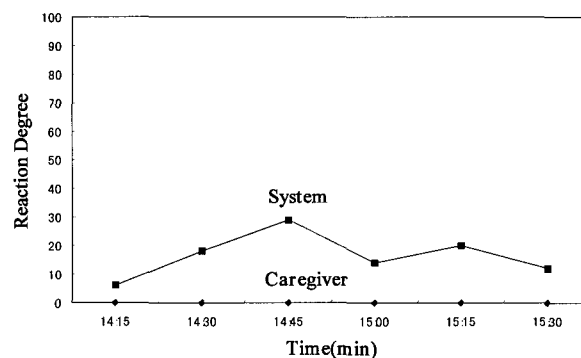
Figure 6 shows a comparison of reaction degrees of subject to each response of both caregivers and system. The degrees were induced by a ratio of response of caregivers or system to reaction of subject. It was noticed that subject made reactions more actively in interaction with system than with caregivers.

Though subject had more frequent interaction with system as shown in the above figures, it was not shown whether a natural and smooth conversation has constantly been built. Therefore, it is important to study what emotional states subject preserves during a virtual conversation with system. From this investigation, moreover, we might see how effectively system maintains a natural interaction. Thus, this study is useful for evaluating whether system gives user emotional burden or peace.

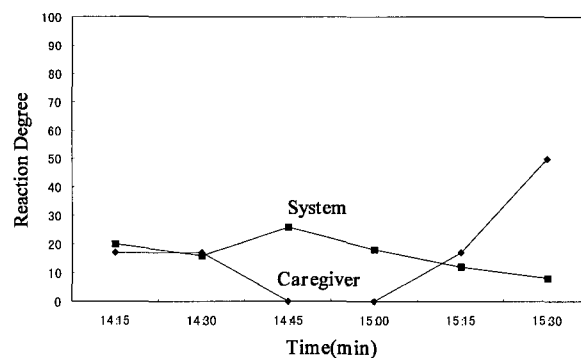
We first analyzed reaction patterns of subject to responses of both caregivers and system, respectively, as a further investigation of figure 6. His reactions were then divided into several kinds of components. As a first component, he showed reactions of asking back to get or confirm agreements, particularly when he heard necessary information from caregivers or system as information provider. As a second component, he showed reactions of asking back twice when the answers to his questions were different from his expectation, or unsatisfied with his demands. Finally, he showed affirmative reactions



(a) Asking back (once)



(b) Asking back (twice)



(c) Affirmation

Fig. 7. Comparison of normalized frequencies of each reaction component to response of both caregivers and system, respectively

with a simple response such as "yes" or "I see". Figure 7 shows the results of the analysis, indicating comparison of normalized frequencies in each case of three components of reactions.

The notable differences were not shown in components of asking back once and affirmation. In component of asking back twice, however, he showed some reactions to response of system, whereas there was no reaction to response of caregivers. His reactions to system were found particularly when a virtual conversation between

them was not built smoothly. As a result, an unnatural interaction might bring some uneasiness to him, or aggravate an emotional instability.

DISCUSSION

As one of the evaluation results, first of all, we could see that speech recognition accuracies were not satisfactory owing to the slurred speech with regional dialects and characteristic accents of subject. However, it was noticed that chiming with him made virtual conversation more smoothly. Accordingly, he might feel as if system heard and understood his complaints or demands curiously and sometimes seriously. Secondly, system has a possibility to provide an immediate response to his demands as shown in comparison results in figure 5. Finally, subject had an active conversation with system as shown in figure 6. Therefore, system might be expected to lighten the burden of nursing works for caregivers at nursing facilities or at home, particularly during their busy time-interval, by letting system interact with their patients who wish to get some conversation. Moreover, emotional calms or such rehabilitative effects for patients were also expected through a mutual communication with immediate response whenever patients want.

However, there are essential issues to have to be solved in two respects. One thing is that subject has been confined to only one dementia patient in this study. Therefore, the proposed system should be evaluated on different patients with different symptoms of dementia. For this case, system has been already equipped with extensional functions to be adaptable to different dementia users by registering their individual utterance patterns. Besides, system has been designed to be flexible to different care environments such as nursing facility or home.

As illustrated in figure 7(b), subject showed no any reactions of asking back twice in interaction with caregivers because he got satisfactory answers to his demands through natural interaction. However, it was found that there were reactions of asking back twice or more when system was introduced. It occurred mainly due to a degradation of speech recognition, resulting in unnatural conversation between them. It eventually developed an agitation or uneasiness in interaction with system, so that he might have some kind of emotional stress or lack of emotional stability. This is the other issue we should take into account when we design dialog

system for dementia patients.

This study showed that system should be designed lest any stressful burdens were given to user in mutual interaction. Therefore, the future works should be considered to deal with an improvement of speech understanding for providing the most relevant answer to demands of users. Particularly, it is indispensable to handle the speech of the elderly with regional dialects or accents. Moreover, there is one thing to remember from the evaluation results. It is about roles of nonverbal communication such as emotional sympathy, body touch, etc., in human conversation with patients. Actually, caregivers often talk with their patients while taking their hands. Those actions also build a new type of mutual communication through a nonverbal interaction in addition to human speech.

CONCLUSION

This study focuses not only on increasing QOL of the elderly with dementia but also on decreasing the nursing burden of caregivers. In this paper, we proposed the communication aid system and applied it to an elderly patient with severe dementia in actual environment of nursing facility. As results of survey, it was revealed that the proposed system showed immediate responses to demands of dementia patient in interaction, so that it allowed patient to take an active part in conversation. Therefore, the system showed a possibility to be helpful for the nursing works of caregivers at nursing facilities or at home.

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