

## 치매노인을 위한 자동대화시스템

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### Automatic Dialog System for the Elderly with Dementia

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#### 요약

본 연구는 치매노인환자의 생활의 질을 향상시키기 위한 대화시스템의 개발에 목표를 둔다. 제안된 시스템은 주로 세가지 모듈, 즉, 음성인식, 시간테이블에 의해 구분된 대화 데이터베이스의 자동검색, 그리고 간호사의 녹음음성에 의한 응답 등으로 구성되어 있다. 우선 치매환자가 요양 시설에서 자주 발화하는 대화의 내용을 조사하고, 그들의 발화 음성을 인식하고 적절히 응답하도록 구성하였다. 시스템의 평가를 위해서 시스템이 도입되었을 때와 도입되지 않았을 때를 비교, 조사하였다. 시스템이 도입되지 않았을 때는 간호사가 자유로이 케어서비스를 행할 수 있도록 하였다. 비디오 촬영을 통해서 대상자의 행동 및 반응을 조사한 결과, 치매환자의 요구를 충족시키는데 있어서 대화 시스템이 간호사들보다 더 응답적이었다는 것을 알 수 있었다. 게다가, 제안된 시스템은 상호 대화에 있어서 환자가 더 많이 말하도록 유도함을 알 수 있었다.

#### I. Introduction

In the recent years, as it has become an aging society both in developed and in developing countries, the overall quality of life(QOL) of the elderly is getting more and more important issue. Particularly, recovering a good health physically and mentally from diseases is an essential purpose of the life for the elderly people. Therefore, such related technologies and secure environments have been designed for independent living and social participation of older persons suffering from several kinds of diseases. For one of the methods realizing them, the mutual interaction based on conversation has been studied for an increase of the mental health-related QOL and rehabilitation.

This study aims to improve the QOL of the elderly

with a dementia[1,2]. The dementia possesses unique features that make nursing particularly burdensome. The mental exhaustion in the course of care at home often leads to problems in terms of caregiver's physical and mental health, owing to the behavioral problems of their family member with dementia. Therefore the QOL of family caregivers is inevitably affected. Namely, family caregivers experience mental stress, burden, and depression as outcomes of nursing activities. Therefore, this study also aims to improve the QOL of family caregivers by lightening their nursing loads to some degree in long-term care[3,4].

In this study, on the basis of these social backgrounds, we have developed the dialog system[5,6,7] of recognizing and understanding demands of dementia patients mainly depending on the techniques of speech recognition. The system was designed to be a good conversational partner to dementia patients whenever they need. As a consequence, the emotional stability might be recovered by the mutual communication, thus having effects of rehabilitation. Furthermore, the system might be helpful for the nursing works of family caregivers at home or professional caregivers at nursing facilities.

#### II. Outline of Dialog System

In order to realize communication between dementia patient and dialog system, the system for dementia patients is required to be equipped with the following functions.

(1) The techniques of a command speech recognition were used for speech recognition module. It is because the dementia patients speak the limited and repeated utterances.

(2) For a response of the system, it is organized to reply relevantly by speech synthesis or recorded voices to user's demands. In this case, a graphical interface with a virtual caregiver is synchronized with the response.

(3) System provides the function of chiming with user or making agreeable responses to demands. This function enables system to interact with user more smoothly and naturally.

(4) System captures the time when incoming voice signals are given to speech recognition module. At next step, it searches the most suitable response out of database at the time, which has been classified into the time schedule of a nursing facility.

(5) In case user asks back, system is designed to make the same response as the previous one, because dementia users have a tendency of reconfirming the answers at a frequent rate.

(6) While the system is responding, the incoming signals are restrained to prevent it from becoming oversensitive.

(7) System has adaptability to switch day-care service of nursing facility to different environments such as short-stay service or home-care service. It is easily realized by substituting for the desired dialog database suitable for a new situation.

(8) System is adaptable to different users with different symptoms of dementia, which is done by registering their individual utterance patterns.

Figure 1 shows the main frame of the dialog system with the functions mentioned above.



Fig. 1. Main frame of automatic dialog system for dementia patients

A block diagram is shown in figure 2 that illustrates how conversation can be progressed between dementia patient and dialog system.

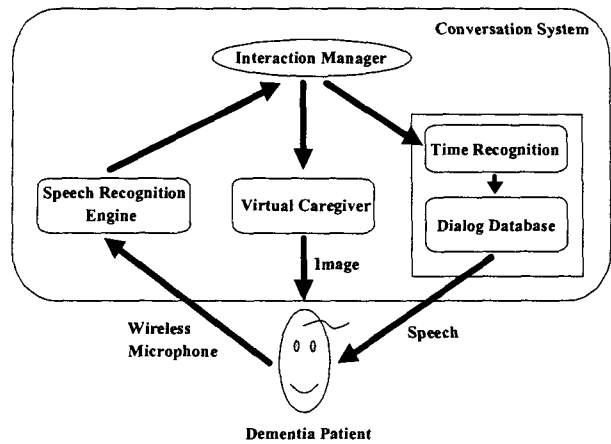


Fig. 2. Schematic diagram of interaction between dialog system and dementia user

In case user speaks to the system, as a first step, both incoming speech and current time are detected by the speech recognition engine and the input signals are then compared with all available hypotheses prescribed in candidate list. In the next step, system retrieves dialog database at the corresponding time interval in case speech recognition is done successfully. As a result, it picks out the most likely and suitable response out of the database and then responds with recorded voices, synchronizing them with a lip of virtual caregiver. If the system fails in recognizing input speech, on the other hands, it makes agreeable responses by chiming with user. Moreover, in case the input time is acquired within a certain preset time interval, the system regards it as a reconfirmation of user to its response. Therefore, the system makes the same response as the previous one. The operating system is then ready for detecting next input speech repeatedly.

### III. Evaluation

#### 1. Subject description

The behavioral patterns of dementia patient were examined at nursing facility for a relevant design of dialog system. In this study, the subject was 72 years old male patient with a vascular dementia. The official approvals from the ethics committee of nursing facility as well as from family members of subject were first obtained in advance.

#### 2. Experiments

The frequently used words of subject in nursing facility were surveyed for building dialog database of system. The several sorts of dialog patterns were

collected and then recorded by two female professional caregivers. The operating experiments of system were performed in the main hall of nursing facility, which was a relatively noisy because it was the place where the nursing home residents have rests or meals.

The comparative study was examined where one of the evaluations was performed with dialog system for 90 minutes of each day during 5 days. In this case, the interruption of caregivers was restricted during the experiment. The other evaluation was performed during the other 5 days without system, where caregivers were allowed to do nursing activities freely whenever subject demanded. During the period of the experiments, occupational therapists observed subjects reactions to system and caregivers, respectively, photographing his behaviors using a video camera.

### 3. Results

For comparative analysis, we examined the frequency of demands of subject, and the frequency of each handling of both system and caregivers to his demands, as well as the corresponding reactions of subject. We then induced the response degree as a ratio of each response frequency of both caregivers and dialog system to demand frequency of subject. Figure 3 shows the comparison of response degrees for both caregivers and dialog system to demands of subject. It was found that caregivers showed the responses by 21% to demands of subject, whereas dialog system showed 79%.

Figure 4 shows the comparison of reaction degrees of subject to each response of both caregivers and dialog system, respectively. The reaction degrees were induced by a ratio of each response frequency for caregivers or dialog system to reaction frequency of subject. When the system was not given, the subject showed reactions by 32% to the responses of caregivers. When the system was given, on the other hand, he showed 50% to the responses of system.

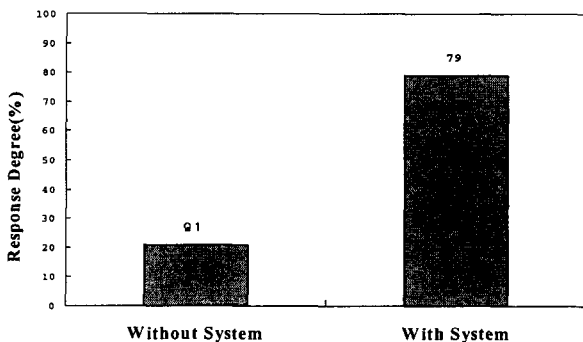


Fig. 3. Comparison of response degrees of both caregivers(namely, the case without dialog system) and dialog system to demands of subject

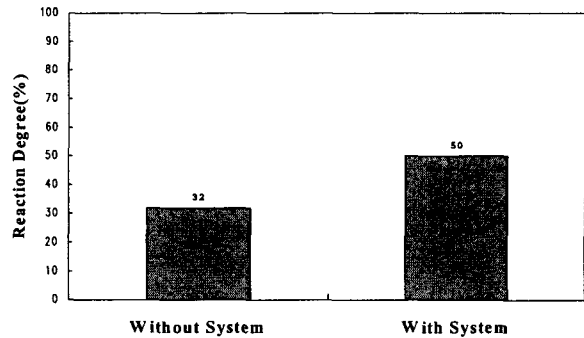


Fig. 4. Comparison of reaction degrees of subject to response of both caregivers and dialog system

Although the above results show that the subject had more frequent interaction with the system, it never indicates that more natural conversation is always conducted. For this reason, the professional therapists examined subject's reactions to each response of both caregivers and system by analyzing the contents of videotapes, as a further analysis of figure 4. By means of this analysis, we could obtain the frequencies of three different reactions such as affirmation, asking back once or twice. Figure 5 shows the comparison of each normalized frequency of three reactions in which the notable differences were not shown, particularly in the components of asking back once and affirmation. On the other hand, subject had no any reactions in the component of asking back twice to caregivers. However, he showed the reactions(n=49) to responses of system.

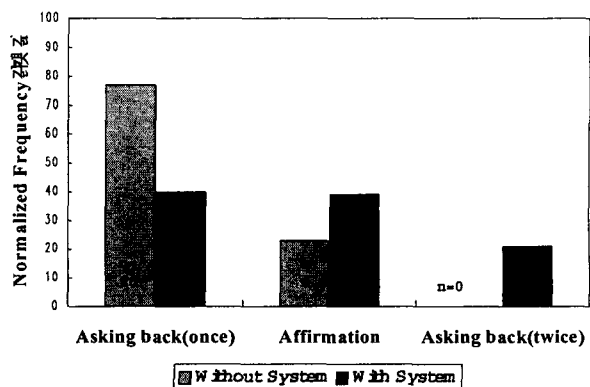


Fig. 5. Comparison of each normalized frequency of three different reactions (n= frequency)

#### IV. Discussion

In evaluation results, we could find that the accuracies of speech recognition were degraded owing to subject's slurred voices mixed with regional dialects as well as his characteristic accents. Nevertheless, the supplementary functions, such as chiming with user by making agreeable responses, keep conversation smooth, so that he might regard system as a good listener.

As shown in figure 3, the system was more responsive in dealing with subject's demands or complaints than caregivers of busy nursing schedules. In addition, he had more active interaction with system than with caregivers as shown in Figure 4. Therefore, the system might be expected to lighten the loads of nursing works at nursing facilities or at home, by introducing system during their busy time. Moreover, the rehabilitative effects might be achieved through a prompt response whenever patients need conversation.

However, it was found that we still had essential issues to solve. As illustrated in figure 5, the subject had no any reactions of asking back twice to caregivers because the interaction between them was natural and satisfactory. It implies that the natural and timely conversation never gives some kinds of emotional stresses or such burdens to dementia patients. When dialog system was introduced, on the other hand, it was noticed that there were occasional reactions of asking back twice. It was mainly due to the failure in recognizing subject's speech correctly, thus causing an unnatural conversation between them. It eventually developed an agitation or uneasiness so that he might feel stressful or depressive in interaction with the system.

#### V. Conclusion

The present study aims to improve the QOL of the elderly who have been suffered from dementia. For realizing this purpose, we have developed dialog system to respond with a natural dialog to their needs. As a result of the survey, we were able to draw two different conclusions. The one thing was that the proposed system was more responsive in catering to needs of dementia user than professional caregivers. The other thing was that the system encouraged the subject to say more than caregivers did. Moreover, the system showed a possibility to lighten nursing loads or burdens of caregivers at nursing facilities or at home.

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