Constructing an Interactive Voice Response Mechanism for Long-Term Care Service

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Abstract
The population aged over 65 is rapidly growing worldwide. It has increased the demand for long-term care. The ultimate goal of health care for elders in long-term care institutes is not only to extend life but to raise their quality of life. However, the World Health Organization Quality of Life-BREF was designed as a self-administered questionnaire. It cannot be applied to elders who are unable to read. Applying information and communication technology, human can use natural speech communicate and interactive with machines. Thus, this study develops an interactive voice response mechanism to measure the quality of life based on the WHOQOL-BREF questionnaire of a novel mechanism. It displays the questionnaire in the form of voice and uses voice recognition to collect answers from the elders. The user-friendly interface requires neither visual attention to read questionnaire nor the use of hands to write answerers. Through natural voice and easy access interface, this mechanism can assist elders to complete the questionnaire independently. The major advantages of self-administration assessment over face-to-face interview are the reduced number of reviewer, time, and the result of the questionnaire better reflects the truth of respondents' feeling or thought. In the beginning phase of the experiment, 15 elderly were recruited as respondents. The result shows that this mechanism is reliable and valid in assessing quality of life of long-term institutes' elderly. This mechanism can also perform statistical analysis which is shown in visual graphs to give advice on making clinical decisions to improve the quality of medical care.

1. Introduction

Due to the continuous progress of the medical technology and medical equipment coupled with the improvement of living standards, the average life expectancy continues to extend and the number of the population aged over 60 is in a more rapid increase compared to the population of young adults in many countries (World Health Organization, 2012). According to the statistics of the World Health Organization (WHO), the number of people aged over 60 would grow exponentially from 11% in the world to 22% during 2000 and 2050 (World Health Organization, 2012). Specific to this change of social structure, the WHO also actively promotes the policies enable the elderly to live as independently as possible and takes the active and healthy aging as the goal. Health is not limited to the focus on the changes in mortality, the amount of morbidity or the presence and absence of disease or physical pain. The WHO defines health as a person having a complete physical, mental and social well-being.

Many assessment tools have been developed in succession in the health measuring methods, such as the Mini-Mental State Examination Scale (MMSE), SF-36 Form (Short Form-36) and Activities of Daily Living Scale (ADLs). However, these tools are all made for the measurement specific to the special symptoms or degree of disability without making the complete conceptual design in the overall quality of life (Fitzpatrick et al., 1992; Tourangeau, Rasinski, Jobe, Smith, & Pratt, 1997). Therefore, this paper uses the WHO quality of life scale as the assessment tool to find out the old people's satisfaction on the overall quality of life.

The WHOQOL-100 questionnaire (World Health Organization Quality of Life -100) is a general health-related quality of life measurement and assessment questionnaire designed by the WHO in combination with scholars in different countries and regions of the world. Since the WHOQOL-100 has 100 questionnaire questions, therefore, after taking into account the time and the applicability of the test, this paper adopts the simplified version (WHOQOL-BREF) re-developed by experts and verified to have good reliability and validity as the questionnaire. The WHOQOL-BREF contains four domains: the physical health domain, psychological domain, social relationships domain and environmental domain. The WHOQOL questionnaire mainly adopts the self-administered method to carry out the test. It can only be administered by the tester through the face-to-face interview in the event that the person involved could not self-administer it due to some special factors. In the past, some literatures have carried out some experiments specific to the testing methods. According to the results, the results produced by the self-administered, face-to-face interview, telephone interview and other test methods have some deviation due to the stimulation given by the tester and the environment control (Jäckle, Roberts, & Lynn, 2010; Lindhjem & Navrud, 2011; Marta-Pedroso, Freitas, & Domingos, 2007). In addition, the literatures point out that the electronic method of answering questions has a higher probability than the traditional paper method for the questionnaire questions specific to personal privacy (Tourangeau, Rasinski, Jobe, Smith, & Pratt, 1997; Tourangeau & Smith, 1996).

The previous literatures point out that in the use of information technology products, it is more difficult for the elderly than the young people (Hossain, 2014; Teixeira et al., 2012), with their low willingness to use mainly due to the complexity of the user interface. To this end, we adopt the speech answering model to provide the elderly

with the most convenient method to fulfill the questionnaire test by answering the questions directly in the oral manner through the questionnaire broadcasted by the system. For the elderly population with the reading or writing inconvenience, the speech method can increase the answering willingness and further understand the self-recognized feeling towards the quality of life of the elderly. It can prevent the questionnaire question from being skipped or missed to fill to reduce the questions missed to answer through the computer's automatic speech system program design.

To enable the elderly to self-assess the quality of life periodically to understand the individual subjective feeling towards life, the speech system is adopted to help gather the feedback questionnaires completed by the elderly in all stages in order to further analyze and track the status of the quality of life of the elderly.
The remainder of this paper is organized as follows: Section 2 describes the establishment of the speech interactive system; Section 3 discusses the research results; and Section 4 offers the conclusions and suggestions.

2. Method

The interactive speech response system proposed in this study is built on the basic target of achieving a human-computer interactive interface, including the speech technology application, database design and development as well as suggestions on the decision support analysis. The detailed description is provided as follows:

2.1 Interactive voice response mechanism process

Figure 1 shows the system implementation process. After the system enters into the home page, it would first carry out the initial setting, including: the elderly identification code, the language selection of Mandarin or Taiwanese as well as whether displaying the questionnaire content or substituting the people with virtual characters in the testing process. In this process, the medical care personnel can assist the input by the speech method. After the setting is completed, it enters into the system test where it first introduces the system test method and process by speech explaining the test method in details to the elderly and then enters into the test questions officially. There are 28 questions in total. In the course of answering each question, if the subject selects the question displaying screen, then only one question would appear on the screen each time to maintain the simplicity of screen; and after the system broadcasts the question in audio form, the elderly can make the appropriate response according to the question they heard. The system would not limit the elderly to answer the questions with the Arabic numerals of 1-5 or the choices from "very satisfied" to "very dissatisfied" in the five-point Likert scale. The system would properly store the values based on the audio information it reads. After the elderly provide the answer, the system would broadcast the answer content for confirm again. In the event that a mistake is recognized, the elderly would be requested to answer the question once again. Because of the reconfirmation of each question by the elderly, it would not display all answers after all questions are covered to simplify the operating and enable the elderly to complete the questionnaire easily. The system would be automatically shut down when the answering is completed.

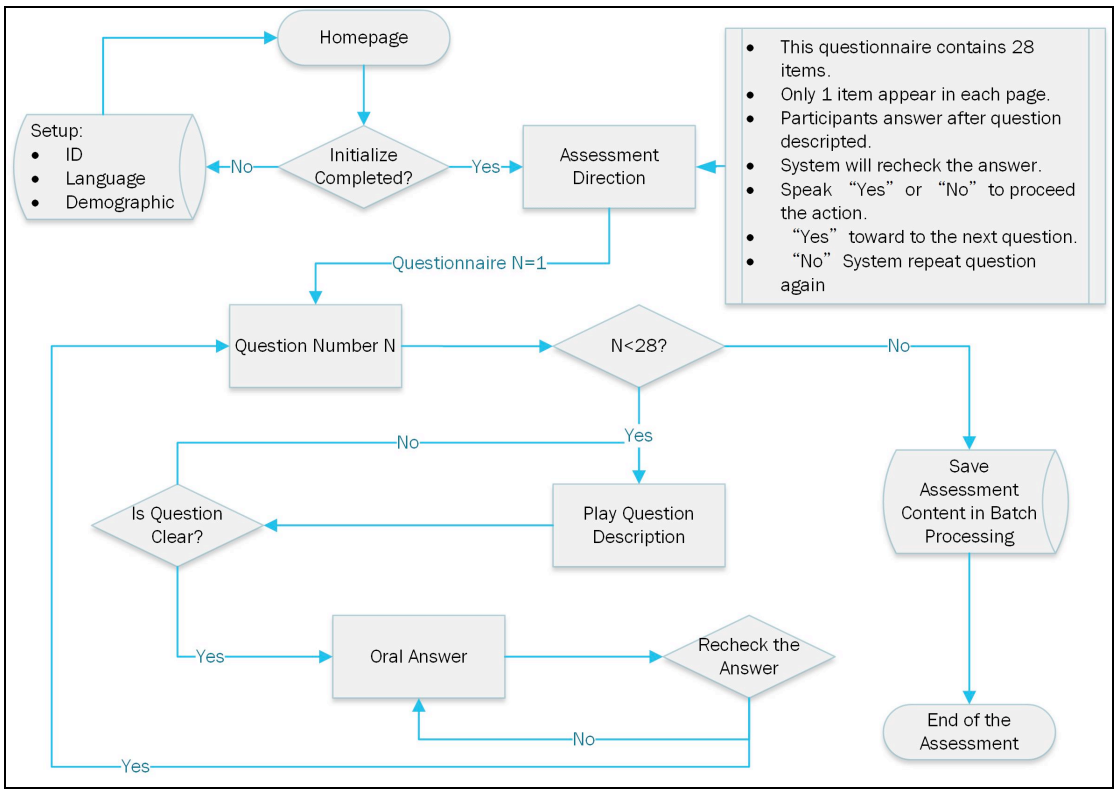

Fig 1 System implementation process

2.2 System architecture

The system architecture in this study is divided into four modules: graphical user interface module, speech technology module, statistical module and decision analysis module, as shown in Figure 2.

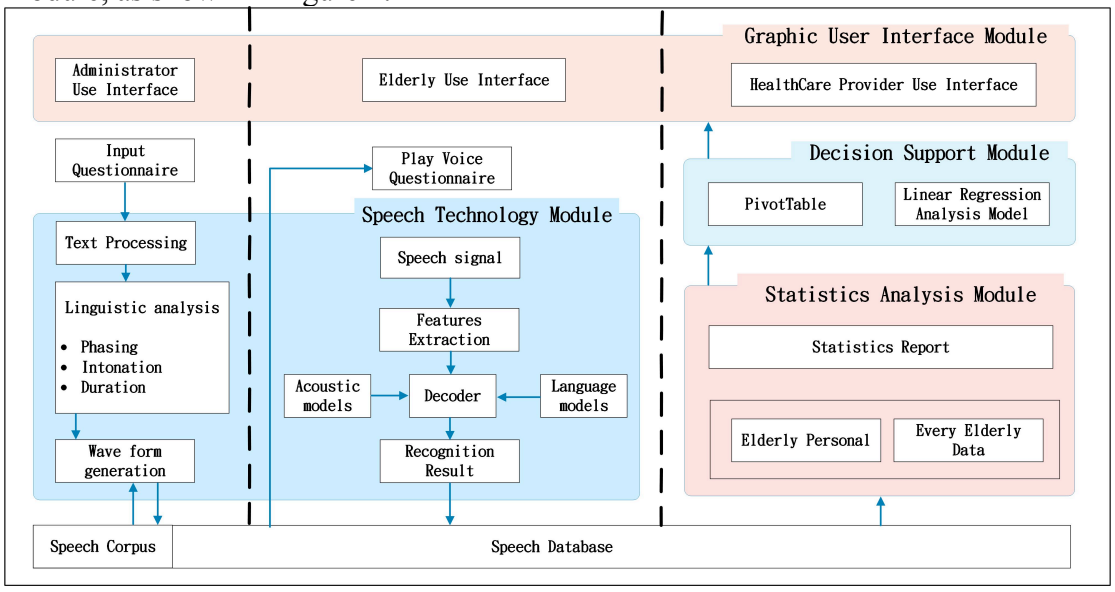

Figure 2 System architecture

2.2.1 Speech technology module

The speech technology module is divided into three parts: the first part is to perform the word processing to the questionnaire content in the form of text file after importing the text information through the text-to-speech technology (TTS), segmenting the sentences in the text content and converting them into the colloquial languages and implementing the numerical value normalization; and then conducting the marker analysis on the word segmentation, tone and part of speech, and the synthetize and export the waveforms after the phonology is generated to the users for the questionnaire test; the second part is to process the audio answers to the questionnaire by the elderly with the Automatic Speech Recognition (ASR) technology, importing the audio information through a microphone to recognize and immediately convert the information into the numerical pattern to be stored in the database, and the last part is the speech control part to allow the users to control the questionnaire through speaking to operate the "OK" to proceed to the next question testing or the "Cancel" to allow the system to re-broadcast the question so that the elderly can correct the answer content.

2.2.2 Graphic user interface module

The system mainly consists of the elderly and health care personnel viewing screens. On the screen used by the elderly presents the system page, namely, when answering the questionnaire on a mobile device. An old person answers the question by way of speaking "one", "two", "three", "four" or "five", then the system would make automatic recognition and re-read the user's answer for confirmation again; and then the person would follow the system instruction to proceed to the next question or re-answer the satisfaction question. The system would display only one question on each page to avoid the complication of screen caused by too many contents. As shown in Figure 3, the question is presented to the maximum visual range to maintain the consistency of screen and the viewing quality.

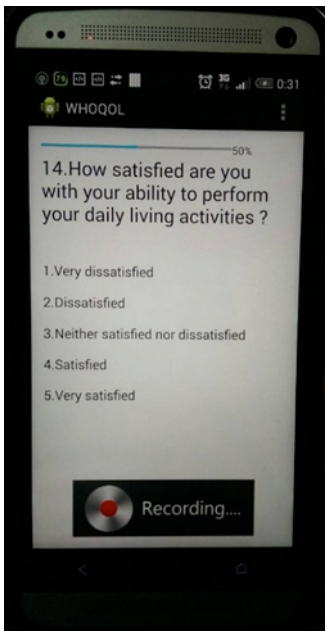

Figure 3 voice response mechanism display

In the health care personnel viewing screen, the feedback data of the completed audio questionnaire test will be processed, converted and presented to the medical care personnel in the form of useful chart information. The information presented mainly includes the statistical charts of the summed value and average value of the simple numeric data and the further decision support suggestion charts. In the classification of data, the comparison would be made between the trend chart of the continuity of the individual old persons before and during the measurement and the numerical feedback by the overall elderly to find out whether the life quality performance of an old person living in a group is normal or different from that of the other elderly; in addition, the medical care personnel are consulted to further understand these special elderly needing care to provide the proper medical treatment and services.

2.2.3 Statistics and analyze module

The score range of each question in the WHOQOL is from 1 point to 5 points. The scoring of each domain is to add up, average and multiply by four the scores of the questions in the same domain, which obtains the domain score. So, the univariate and multivariate regression analysis are carried out on the obtained scores of the four domains through the Generalized Linear Model (GLM) by setting the obtained scores of the four domains as the dependent variables and the basic demographic data as the independent variables.

The periodic test and design is incorporated into the system where in every two weeks, the questionnaire would be automatically pushed to the mobile carriers for periodic tests. Through the periodic answering by the elderly, the system is able to collect the variation trends of the life quality of the elderly in different periods and the questionnaire feedback information in various stages to increase the authenticity and accuracy of the judgment on the satisfaction of the elderly. The numerical values of the answers by the elderly are converted to be presented in the forms of the bar chart, radar chart and box plot through the numerical information stored in the database and the statistical analysis software SPSS20 to analyze the score trend charts of the four domains of the elderly in various periods. Also, the data of all old people having been tested by the questionnaire would be collected and sorted at the meanwhile to develop the overall distribution chart so as to improve the quality of viewing by physicians. We have also incorporated the decision support analysis technology to provide appropriate suggestions for the physicians in making the diagnosis.

2.3 System environment

The system environment can be divided into three parts, including the front-end data collection, mediation analysis software and final data trend analysis chart provided to be viewed by the medical care personnel. As shown in Figure 4, the system conducts the quality of life questionnaire measurement specific to the elderly in the long-term care institutions. The medical care personnel in the institutions can assist the elderly to fulfill the initial registration and setting of personal data. Then the elderly would answer the questionnaire by the oral method and the interaction with the system. After the entire questionnaire answers are completed, the system would send them to the rear end for data analysis and processing and finally present the assessment score distribution trend chart for the use and reference by the medical care personnel.

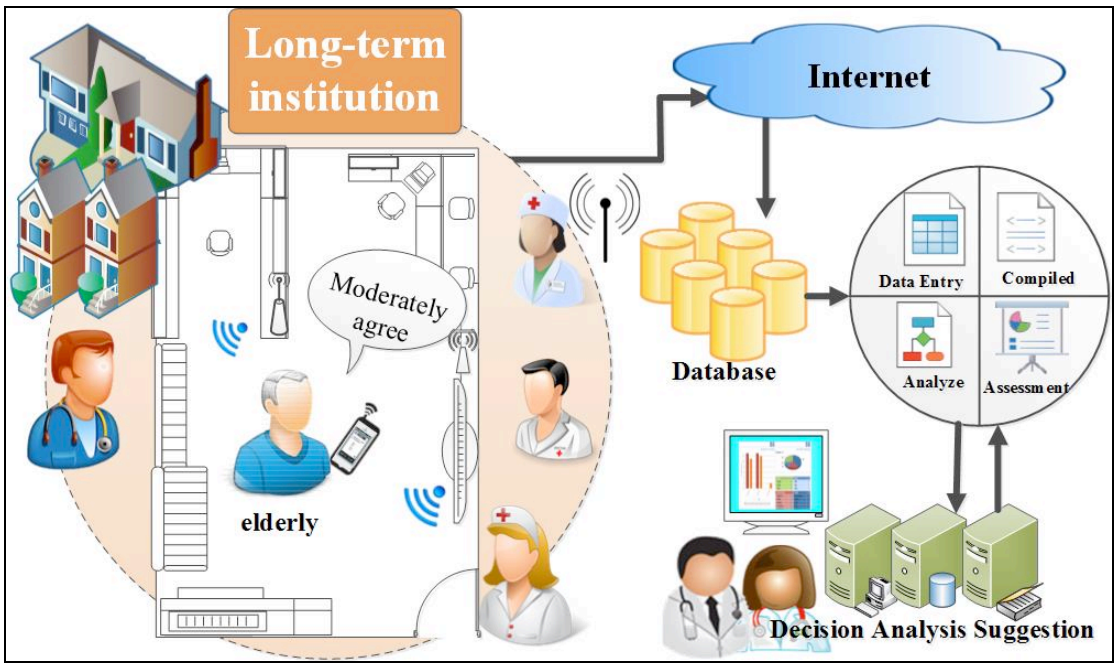

Fig 4 Interactive voice response mechanism system environment

2.4 Development tool

This system is compiled by the Java programming language in the Android development environment. The database is managed by the MySQL software. The interactive audio questionnaire system is downloaded through the wireless network in the institutions. After logging in the account with the personal identification code under the assistance by the medical care personnel, the questionnaire test can be started. At the end of the measurement of each time, namely, time when the user touches the upload command, the cell phone would transmit the assessment and measurement results via the 802.11g wireless technology to the database in one time for analysis and generate the assessment results. These series of data entry, compilation, analysis and final assessment would be summarized in the statistical analysis module. 3.1

3. Data analysis

Table 1 presents the average values for each domain of the WHOQOL-BREF questionnaire. Internal consistency scores for items within each domain were satisfactory, with Cronbach's α scores ranging between 0.67~0.85.
Table 1 Reliability of the WHOQOL-BREF questionnaire internal consistency.

Table 1 Internal consistency of the WHOQOL-BREF questionnaire

WHOQOL-BREF Domain	Number of items	Mean score ± SD	Cronbach's α
Physical Health	7	14.3061±1.96	.674
Psychological	6	13.1905±2.50	.690
Environment	7	13.5397±2.44	.675

Social Relationship	4	13.6071±2.27	.751

3.1 Medical user interface

When elderly finished the WHOQOL-BREF questionnaire, the data transmission over a wireless network, sent to the back-end database for analysis, and shown in visual graphs for health care.

Figure 6 shows box plots of the data relative physical health and gender. The length of the box represents the interquartile range. The middle bar represents the median. Outer edges of the box represent the 25th and the 75th percentiles.

In order to find lower score in four domain, a radar chart are used in this study to display the comparison between the latest three assessment result of an elderly and the average value, as shown at figure 7 which is capable to provide clinical care recommendation for medical staff.

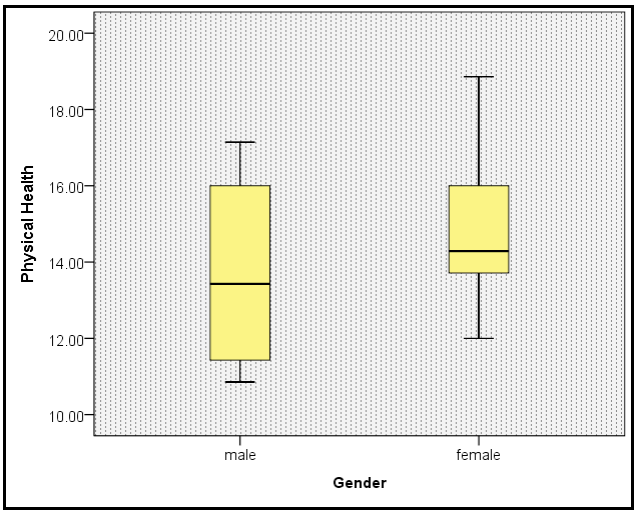

Figure 6 Box plots displaying distribution of physical health in male and female

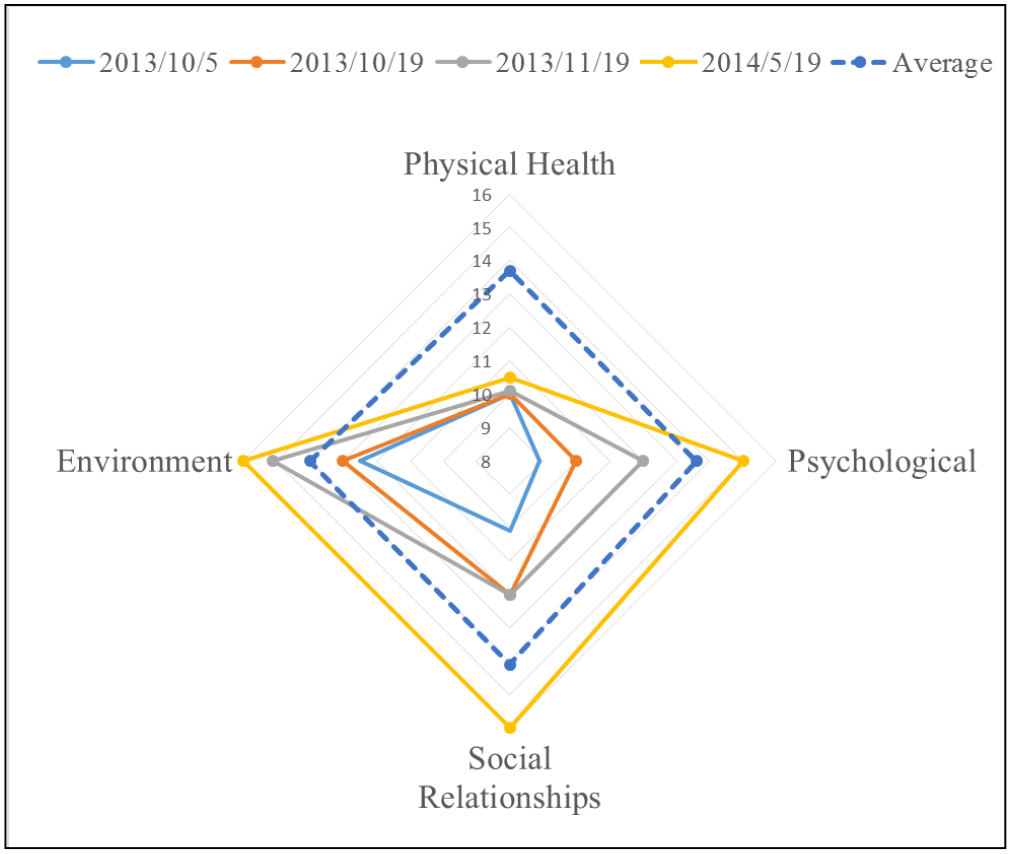

Fig7 Radar chart comparing four scores on four domains

4. Conclusion

In this study, a set of audio questionnaire system in combination with the speech technology is constructed and provided to the elderly in the long-term institutions as the speech answering system of the quality of life satisfaction survey, making the questionnaire testing method easier and thus increasing the willingness of the subjects to be involved in the questionnaire survey. The surveys are performed in a periodic and continuous manner on the elderly to analyze the score trends in different periods. In the tester analysis part, the operating process of the traditional questionnaire is simplified. The answers completed by the subjects would be transmitted through the wireless network to the database for analysis, increasing the efficiency of questionnaire survey. In the medical care personnel viewing part, the data support is presented in the clear and concise charts, improving the medical service quality of the long-term care institutions.

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