An ICT-based supporting system for home-nursing services

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Abstract:

These days, the demand for home nursing in Japan has increased significantly. Along the increase, the shortages of staff and inefficiency of operations have become serious problems. This study aims to develop a system to support the operational efficiency of home nursing. As a thing being of particular importance, we focus on producing a summarized report of a patient's presenting symptom for a medical doctor with several nurses' notes that include unstructured data. A manual process of making the report imposes excessive burdens on nurses. However, the unstructured data contains crucial information, the course of symptoms. In this paper, we demonstrated an analysis of symptom courses, which includes extracting sentences about symptoms and classifying the status of symptoms. Experimental outcomes show that status classification works well, but there is room for improvement in both symptom extraction and status classification. As a future work, to improve the accuracy of symptom name extraction by human annotation and symptom classification by learning word dependencies. The symptom analysis system will contribute to support the time-consuming paperwork in home nursing.

Index Terms— Home-nursing, summary, data analysis, NER, NLP, ICT

1. Introduction:

The demand for home-nursing services, in which the nurse taking care of the patient's medical needs and assisting in medical care, has been expanding along the rapid aging in Japan [1]. However, the number of people who engaged in home-nursing is lacking. From 2016 to 2018, the job opening ratio for nurses in home-nursing facilities was the highest in all kinds of nursing facilities [2]. This fact means that the lack of nurses in home-nursing facilities is becoming a severe problem. Moreover, the affair of home-nursing trend to become inefficient because of the required individualized treatments. To address these problems, the productivity of home-nursing is needed to be increased so that they can reduce wasteful costs and burden on the field, which leads to raising the compensation and keeping the turnover low. Making nursing services it more efficient is by no means easy. Therefore, making an effort to reduce time-consuming and routine paperwork could be an effective way. Thus, some home-nursing offices have been rapidly promoting the use of ICT. As of

2018, approximately 43.1% of the offices have converted their home-nursing records to electronic format.

Figure 1. Shows required documents for home-nursing and the processes of preparing each document.

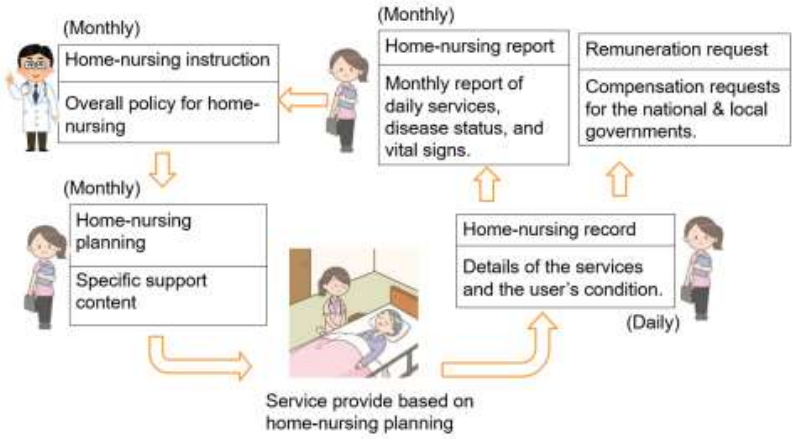

Figure 1. Home nursing paperwork

The existing supporting system using ICT realizes some functions such as automatic generation of remuneration request documents, auto-reflection of nursing service records, and business analysis. These functions are the utilization of structured data. Nevertheless, there is still a lot of unautomated paperwork because unstructured data, such as description of the disease course, is hard to be handled, especially in medical fields, and the descriptive format is not complete due to the lack of time spent on recording.

The survey for nurses in home-nursing offices proved that a simple ICT system introduction is not efficient. The ICT system used in the survey auto-reflects previous descriptions of nursing records, nursing reports, and nursing planning papers. The nurses recognized the introduction of a simple ICT system as useful in terms of document management. However, they did not recognize the effectiveness of overall business efficiency, and few nurses recognized a reduction of burden on the works. Therefore, a more effective supporting system should be implemented for home-nursing. Utilization of stored electronic data is desired to improve operations and reduce the burden on home-nursing workers.

Our study has developed a supporting system for improving the efficiency of document preparation work using text data. Among various paperwork, preparing a nursing report is time consuming and important base of other papers. In preparing a nursing report, summarizing and reporting the monthly symptom courses of each patient is the most important task. Therefore, we discuss with the analysis of the symptom courses in this paper. The analysis of disease courses is expected to be used for the creation of papers, such as monthly records, nursing instructions, and nursing plans.

2. RELATED WORK :

As already mentioned in, the important task of this study is to summarize patients' symptom courses by analysing medical text data. This section introduces the related works concerning medical text data.

As for the analysis of medical text, a natural language processing (NLP) tool for medical use developed in [4]. The medical text analysis system extracts disease representations and judge the factuality of the text. On the way to developing the system, extraction of disease representations, which is called Entity Recognition task in NLP, are conducted with machine learning labelling based on both character segmentation and word segmentation. From a comparison between two segmentation, the study turned out that the character segmentation based extraction is superior. This finding enables the recognition of disease and disorder names with high accuracy. Factuality judge distinguish the text about disease between current positive findings (P) and others (N). By Integrating Entity Recognition and P/N classification, the accuracy of Entity Recognition is improved. However, the purpose of home-nursing is to provide sustained medical care for the patients since observing detailed changes in symptoms not only positive or not is required.

Analysing hospital medical data is the most popular topic in medical text analytics. A discharge summary handled in a hospital is a summary of medical history, findings at the time of admission, and medical care during hospitalization which is prepared when the patient discharge from the hospital. Iwaanakuchi [5] developed a medical records table from the EF file of DPC that make easy understanding of medical history for supporting of preparing discharge summary. However, the discharge summary and nursing report are different, and the nursing report includes the patient's symptom courses. For the discharge summary, the standardization of the description to treat text as constructed data has been widely proposed. However, the standardization of the description has a problem with scalability and is difficult to disseminate. Furthermore, standardization of text has not been promoted widely than in hospitals in home-nursing service, so the problems of handling unconstructed data remains.

3. PROPOSING SYSTEM:

This section presents the objectives and requirements of the system design and proposes a supporting system that meets the requirements.

A. Research Objective:

To solve the problems that the home-nursing business has, the objective of this research is mainly to support the efficiency of paperwork in home-nursing. Among the various kinds of paperwork, below three operations that existing systems and researches do not support adequately should be supported. • Preparing monthly home-nursing report • Preparing monthly home-nursing instruction paper • Preparing monthly home-nursing planning paper Moreover, a monthly home-nursing report is an important reference of the other two papers and takes a great deal of time to create. Therefore, this paper focuses on the monthly report as a first step of supporting. Fig.2 shows the overall structure design of proposing system, which supports the above three pieces of paperwork.

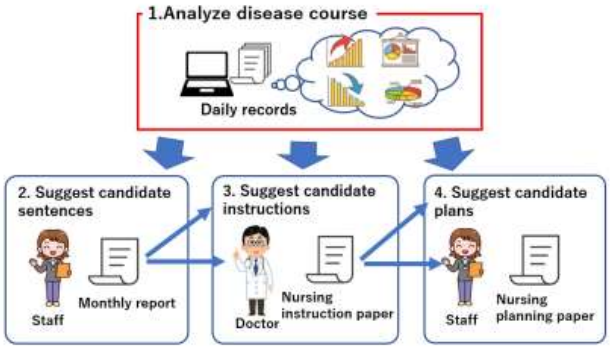

Figure 2. Overall proposal system structure

B. Requirement :

To achieve the objective of this study, there are two subjects. The first is a reduction of the wasteful tasks and the second is a reduction of manual tasks. Paperless is an approach to the first task and has already been in use in many home nursing offices. The approach to the second task is the implementation of the supporting system that replaces the tasks having been performed by people. This study deal with the second approach. The system contributes to realize the high efficiency of the paperwork but needs to be considered high reliability for medical treatment cost and education for the system introduction. The main task of preparing a homenursing report is to create descriptions that express user's symptom course for each month. To support the main task without standardization of input format, proposing system is required to handle free writing text. Acceptance of free description increase the amount of information from data, eliminates new education costs, and realizes scalability. In a home-nursing report, the symptom course is made by sentence extraction from daily records. Therefore, the system makes a summary by not abstraction but extraction. Then extraction of important sentences about sentences is helpful for the main task. Analysis about symptom courses leads to distinguish of the sentence importance and help the nurse to assess the patient's condition. Realizing the extraction with no leakage connects to the system reliability. Furthermore, the output that help the task efficiency is required. In the future, the output that making other paperwork efficiency is desired such as the figure about symptom courses, which help assess of symptoms visually.

1) Handling free writing text.

2) Analysing symptom courses.

3) Extracting important sentences about symptoms without leakage.

4) Making output that meet the efficiency needs.

5) Making output that useful for other paperwork.

C. System Structure:

The service provider inputs the home-nursing record as conventional from the user's home and others. (Requirement 1) Then, the daily records are analysed every month by proposing a system.(requirement 2) After analysing, the system output the user's symptom courses and the candidate sentences for the monthly report.(requirement 3 and 4) In the home-nursing office, the nurse selects the sentences to be included in the report from candidate sentences regarding the symptom courses. Finally, the nurse edit and add sentences as needed. The monthly report is completed and the system learns the selection and edition by nurses to

improve the system itself. The proposing system does not automate all tasks for preparing monthly reports because the reliability of the report is crucial and humans should confirm it. However, the system reduces the workload of nurses by introducing a selection format.

The detail system structure is as follows. Each number of process corresponds to the above requirements number.

1) Pre-processing
   - split by sentence and token.
   - remove line breaks and spaces.
   - unify double-bytes and half-byte characters.
   - correct spelling mistakes
   - Format data to csv.

2) Extraction

   - extract the matches between the strings split with character base and the symptom name from the dictionary.
   - extract the matches between the tokens and the symptom name from the dictionary.
   - integrate the above two matches.
   - extract all sentences include symptom names.

3) Status classification

   - find the matches between before and after expression of symptom names and regular expressions determined for each status.
   - determine the symptom status for all expressions about symptom according to priority.

4) Importance determination

   - classify the sentences with each symptom and sort by time series.
   - determine importance of sentences with monthly changes in symptom status.

5) Output

4. IMPLEMENTATION:

To realize the proposing system, the four functions below are implemented as a trial. In this section, the details are mentioned of each function.

A. Pre-processing

To use in analysis, the descriptions are divided into both sentences and tokens. Sentences are recognized by reading marks and line breaks. Tokens are segmented with Japanese morphological analyser Mecab and practical medical terminology dictionary ComeJisyo [6]. Then, the line breaks and spaces are removed. Alphabets and numbers are unified into half-byte characters, and Katakana characters are unified into doublebyte characters. Spelling mistakes are modified by hand. There are no missing values in the description of symptoms of the dataset. The data is converted to CSV form, of which rows are Date Time columns are sentences and tokens.

The system extracts symptom names using the corpus named ManbyoJisyo [7]. ManbyoJisyo is a large corpus of symptom and disease names from electronic medical records and discharge summaries. In ManbyoJisyo, each item has reliability level and International Classification of Diseases (ICD) 10 code. Three conditions using reliability level and ICD10

code are applied to use of symptom names and their extraction accuracy are compared. The matches between symptom names in the restricted range of ManbyoJisyo and the tokens or the strings split by n letters (called n-gram) are extracted. The numbers of split characters are from 1 to N, which is the maximum number of characters of the symptom name that matches the corpus in the text. The token-based matches and n-gram (1 to N) based matches are integrated according to the following rules where two or more matches exist in the same place. 1) Token-based matches have priority, 2) Maximum numbers of characters have priority. Furthermore, matches between frequent words of the records for a month and all symptom names in the Manbyo corpus is extracted. Frequent words are considered because they are basically important words in the text, and the extraction leakages cause overlooked of patients' symptoms. The matches obtained above are treated as the symptom names.

B. Status classification

After extracting symptom names, the system classifies the status of the symptoms by focusing on before and after expressions. The statuses are divided into 7 sections, stable, negative, recover, worse, suspect, mild, and severe. For each section except stable, regular expressions are defined and applied to matching with before and after expressions of symptom names. Specifically, the regular expressions about before expressions are applied for both tokens appearing just before the symptom names and modified source of the symptom names. Then, the regular expressions about after expressions are applied for tokens just after the symptom names and a modifying destination. The matches of after expressions and the modified source/modifying destination have the priority where the plural matchings exist. The modification structures are determined with CaboCha, yet another Japanese dependency structure analyser? The status of symptom names that no matches for regular expressions in before and after expressions are classified as stable.

To learn the changes of the symptoms in a month, the sentences about symptoms are classified with each symptom and sorted by time series. The significant changes in a month are important sentences that should be included in a monthly report such as recovery and worsening.

5. RESULT AND CONSIDERATION:

The dataset used in the experiment is papers of a man and a woman for one month that the home-nursing office provides. The privacy information such as personal name and address is eliminated in advance.

A. Symptom names extraction

The precision, recall, and F-measure are calculated for three conditions with comparing the answer, which is the human-annotation. Three conditions of the ManbyoJisyo are as follows.

1) Reliability level: C-S, ICD code: except -1 missing value.

2) Reliability level: C-S, ICD code: except missing value.

3) Reliability level: F-S, ICD code: no restriction. The reliability levels are divided from F to S depends on how to assign ICD code to the symptom name. From F to D are based on automatic machine assignment. -1 in ICD10 code imply symptom name such as having 4 or more ICD code, and having no existing ICD code. Table I show each assessment corresponding the condition of the same number. Among the three, condition 1 output the highest precision, condition 3 output the highest recall rate, and condition 2 output the highest F-measure. In this research, the recall connects to the reliability of the system and the

precision connects to the effectiveness. The priority is the reliability in the medical field, so condition 2 or 3 is available. The more improvement of the recall rate and the precision is needed. The precision will be improved by the learning from human-annotation. There are some symptom names peculiar to home-nursing that ManbyoJisyo do not treat. Therefore, the recall rate will be improved with the function that predict symptom names from appearance frequency and the before and after expressions.

Table 1 Condition Analysis 1

	Precision	Recall	F-measure
Data 1	65.72% (52/80)	60.87% (53/86)	63.27%
Data 2	87.29% (21/29)	66.49% (24/35)	75.98%
Data 1 & Data 2	74.63% (62/107)	65.69% (77/121)	66.29%

6. CONCLUSTION

As a first step in realizing a business support system for the home health care business, we implemented a symptom analysis system. The extraction of symptom names are conducted with three conditions for the range of the medical dictionary. Precision, recall rate, and F-measure are compared for each condition. Both precision and recall rate is required to be more improved by further functions, leaning from the human judge and prediction from appearance frequency and before or after expressions. The classifying the status of symptoms performed with high accuracy, but there is a problem in the perception of dependency. However, the problem is expected to be solved by the introduction of a more accurate engagement analyser. Besides, judging from the course of symptoms, extracting key sentences will assist in the preparation of papers. We proposed a system of symptom analysis adapted to home care and conducted experiments on sample data. Some problems were also observed, but will be improved by future works.

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