ACS: Asthma Care Services with the Help of Case Base Reasoning Technique

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Abstract

Asthma care services help avoiding frequent attacks to the asthmatics and save time of the expert physicians. In case base reasoning (CBR) previous experience is being used instead of getting lost. This paper presents a knowledge support system for asthma care services with main emphasis on CBR. The framework of the knowledge support system (KSS) has been discussed in the paper. The KSS has three main components user interface, CBR process which calculates similarity index for new cases based on a threshold value and Ontological Process which generates the care plans for the matched cases and saves the care plans in CBR container. This developed system will help in improving the quality of life of asthmatic patients.

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1. Introduction

Asthma is a major cause of chronic morbidity and mortality throughout the world and its prevalence has increased considerably over the past 20 years. At present 100 to 150 million people around the globe suffer from asthma among which estimates indicate a prevalence of 10% to 15% in 5-11 year old children. India has an estimated 15-20 million asthmatics. There is no cure for asthma, but symptoms can be controlled with access to prompt medical care, appropriate medications, proper self-management, and trigger reduction. When asthma is controlled, patients can prevent most attacks, avoid troublesome day and night and remain physically active. The goal of asthma care is to control the clinical manifestations and control the expected future risk to the patient such as exacerbations. In this paper a Knowledge support system for asthma care services (ACS) has been developed with main emphasis on case base reasoning approach.

2. Materials and methods

2.1 Knowledge support system

A knowledge support system is a system that supports decision making using knowledge base tools and techniques. One such tool is Case Base Reasoning (CBR), which is the process of solving given problem based on knowledge gained from previous similar problems.

2.2 Case Base Reasoning

CBR is a process to recall similar experiences in the past for solving the current (new) problem. After solving this problem the experience gain is saved in the memory as past experience and is further recalled from the memory if similar situation arises.

Schmidt et al. presented the results of the MIE/GMDS-2000 Workshop on ‘Case-Based Reasoning for Medical Knowledge-based Systems’. Mantaraset al. reviewed a representative selection of CBR research in the past few decades on aspects of retrieval, reuse, revision, and retention. Finnie et al. reviewed some existing models of case-based reasoning such as the R 4 model of CBR and proposed a R 5 model, in which repartition, retrieve, reuse, revise and retain are the main tasks for the CBR process. Ocampo et al. focussed on the construction of diagnosis support tools for Acute Bacterial Meningitis, reporting a comparative assessment of the quality of a Clinical Decision Support System (CDSS) resulting from the application of CBR to that of an existing CDSS system developed using a Bayesian expert system. Ahmed et al. presented a framework to process and analyse data from a pulse oximeter which remotely measures pulse rate and blood oxygen saturation from a set of individuals. Begum et al. developed a case-based decision support system to assist clinicians in performing such tasks. Darabiet al. designed a case-based-reasoning (CBR) model in order to assist a physician to diagnose the type of disease and also the needed therapy. Chen et al. applied artificial intelligence technique to generate personalized diabetes care plan. The authors used case-based reasoning to search matched diabetes care plan according to personal conditions.

The Case Base Reasoning cycle is shown in Fig. 01:

1. Retrieve: From the data base of case base reasoning system, cases having higher similarity to the new case are retrieved. The cases retrieved depend upon a threshold value.
2. Reuse: It is the quite simple process. To find the solution of new problem, one can reuse the cases saved in the memory. The old case in the memory which is most similar to current problem is the solution of the current problem.
3. Revise: The feedback of the system is obtained according to the given solution. In feedback the grading is given according to usefulness. These feedbacks are saved in the case base reasoning system for further requirement.
4. Retain: According to the diagnosed results and feedback of current problem one can adapt or revise the database with current problem so that the current problem can be reused if required. The retain phase is the learning phase of a CBR system.
5. Similarity: The similarity calculation is a necessary process in CBR. The similarity measure is the calculation of distance between two symptoms (local similarity) and distance between two cases (Global Similarity).
3. The knowledge support system framework for ACS

In this section discusses the development of KSS framework for ACS is discussed. The developed system will help in providing the Asthma ontology. The development steps for the framework are shown in fig. 02 and the architecture of the developed system is displayed in fig. 03. This framework comprises of three main processes.

1. **User interface:** This module is the place where users enter their profile, questionnaire and lab test results. The entered data is used in case base reasoning process. The user interface after processing through CBR processing and ontological processing, displays the generated care plan.

2. **Case base reasoning container:** Case base reasoning process calculates similarity index for new cases based on a threshold value.

3. **Ontological process:** Ontological process generates the care plans for the matched or unmatched cases saves and the care plans in CBR container. These care plan are further used when similar problems occur.
4. Case base reasoning CBR process

Once the user inputs his/her symptoms these are sent to the CBR process. The CBR process helps in determining the similarity between new and old cases (Fig. 04). In this process questionnaire is prepared to collect the information about the patient. If the patient is asthmatic, the level of control of a patient is calculated Using Fuzzy Inference System and is verified by Pulmonary Evaluation Test. Next the Global Similarity (GS) index is calculated. If GS > ε then similar case is found, which is used to generate care plan. This is then sent to ontological process. There are two type of similarity check as follows:

1. Local Similarity (Measure the distance between two symptom )
2. Global Similarity(Measure the distance between two cases )

Local Similarity: New case and past case help to determine the local similarity by calculating the distance between individual symptoms. The local similarity is different for numeric and symbolic features:

For Numeric symptom:
\[
\delta_l (\text{New Case, Past Case}) = \frac{(P - N)}{\text{max difference}}
\]  
(1)

For Symbolic symptom:
\[
\delta_l (\text{New Case, Past Case}) = 0 \text{ if } P = N
\]  
(2)
\[
\delta_l (\text{New Case, Past Case}) = 1 \text{ otherwise}
\]  
(3)
Where: P = Value of \(i^{th}\) Cases, N = Symptoms for new case, l = Local Similarity, max difference = max distance between P and N

Global Similarity: The global similarity is calculated by determining distance between new and past cases. Local similarity has the role of calculating global similarity because the every symptom distance is used for computing the distances between the cases. Distance between two cases is given below:

Similarity Index: Let similarity index be defined as GS.
\[
\text{GS (Problem, case)} = \frac{\max \Delta (\text{New Case, Past Case})}{\Delta (\text{New Case, Past Case})}
\]  
(4)
\[
\Delta (\text{New Case, Past Case}) = \sum_{i=1}^{m} \delta_l
\]  
where: m = number of symptoms
\[
\text{Best Solution} = \min \Delta (\text{New Case, Past Case})
\]  
(5)
Where: Min [\(\Delta (\text{New Case, Past Case})\)] = minimum distance between problem and case, 
\[\Delta (\text{New Case, Past Case})\] = Distance between problem and case, 
Max [\(\Delta (\text{New Case, Past Case})\)] = maximum distance between problem and case, 
\(\varepsilon\) = Threshold value by learning knowledge

If threshold value is higher this means similarity between cases is high and lesser threshold value indicates similarity between cases is lesser. If data base is large the value of threshold must be high but in case of small database threshold value must be low to find the similar cases, so for a large database the threshold could be taken large which will increase the accuracy.
5. Ontological Process for ACS

In this process the basic care plans are generated using the levels of control (Fig. 05). These care plans are then transferred to user interface process for the user and are also saved in basic care plan database.

6. Results and Discussion

Following case was given by the user (Table 01). After processing this case, it was found similar (similarity index $GS_1 = 0.4$ and $GS_2 = 2.4$ calculated using Table 01 and Table 02) to the case ids 11 and 2 as shown in Table 02 and 03 respectively. Basic care plan generated for the patient is shown in the form of result, medication and care plan in boxes (1, 2 and 3).
Table 01 Patient (user) symptoms

<table>
<thead>
<tr>
<th>ID</th>
<th>Dry Cough</th>
<th>Trouble in breathing</th>
<th>Cyanosis</th>
<th>Freq. Cough sp. At night</th>
<th>Wheezing</th>
<th>Trouble in sleeping</th>
<th>Late for college and work</th>
<th>Chest tightness/ Pressure</th>
<th>Difficult in talking</th>
<th>Less energetic during play</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>0</td>
<td>5</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>5</td>
<td>Some times</td>
<td>Yes</td>
<td>4</td>
<td>yes</td>
</tr>
</tbody>
</table>

Table 02 Similarity Table

<table>
<thead>
<tr>
<th>ID</th>
<th>PEF</th>
<th>FEV₁</th>
<th>FVC</th>
<th>FEV₁/FVC</th>
<th>FEF₂₅-₇₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>3</td>
<td>1</td>
<td>1.2</td>
<td>45</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Table 03 Pulmonary Evaluation Test (Lab test)

<table>
<thead>
<tr>
<th>ID</th>
<th>PEF</th>
<th>FEV₁</th>
<th>FVC</th>
<th>FEV₁/FVC</th>
<th>FEF₂₅-₇₅</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>3.14</td>
<td>0.90</td>
<td>1.36</td>
<td>49.2</td>
<td>0.3</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1.4</td>
<td>40</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Box. 01 Result

Uncontrolled asthma according to test and FIS

Box. 02 Medications

Take inhaler and use quick relief medications

Box. 03 Care Plan

Do exercise and prevent from the exposed to a trigger (a substance or event such as cigarette smoke, dust, animal or pollen that cause a reaction)

7. Conclusion

Nowadays lots of important data and approach of the medical research are lost due to not using IT approaches, so ACS is a useful approach for medical purposes. ACS help inexperienced physician to take professional decisions regarding patients and it is also helpful to make automatic care plan for the patient. If proper number of expert staff is not available to check the patient and make a care plan than ACS approach may also be very useful.

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References