Knowledge bases for arterial hypertension strategy selection: development and estimation

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Introduction. The information technologies give the possibility to formalize and structurize knowledge in the knowledge base (KB). Thus, knowledge is available for computer processing [1]. The two KB developed comprise the same knowledge amount: „New European Hypertension Guidelines, 2003”.

Goal. To build two KB and computer systems for decision making on strategy concerning arterial hypertension (AH) patients and to compare them.

Methods. Authors used rules and frames to formalize knowledge. Decision making are divided into three levels:
1. The lowest level: based on symptoms, the patients blood pressure (BP) class, risk factors (RF), number of target organ damage (TOD) and the AH-related clinical conditions (RCC) are detected.
2. The medium level: total risk is calculated.
3. The highest level: optimal AH strategy for the patient is determined.

Figure 1 illustrates the decision making tree on the medium level for patient with blood pressure class A.

Fig. 1. Decision making tree for blood pressure class A patient on the medium level

On the highest level the AH strategy is determined considering the total risk calculated on medium level and blood pressure class (O, A, B, C). Figure 2 shows the decision making tree.

On the highest level final conclusion is made choosing one from 9 strategies:
1. The basic strategy for all patients.
2. Diabetic strategy for patients with diabetes mellitus.
3. Seven individual strategies, which depend on the number of patient risk factors, blood pressure class, RCC and the TOD: 
a) Strategy 1 - equal to the basic strategy 
b) Strategy 2 - before the start of drug therapy observe for 12 months, measure blood pressure 1-2 times a week 
c) Strategy 3 - before the start of drug therapy observe in 3 months, measure blood pressure every day 
d) Strategy 4 - before the start of drug therapy observe more than 12 months, measure blood pressure 1-2 times a month 
e) Strategy 5 - measure blood pressure every 2 months 
f) Strategy 6 - begin drug treatment 
g) Strategy 7 - Immediate Intensive Drug Treatment.

The recommended system strategies for an individual patient is composed of 3 components: a basic strategy + Individual Strategy (str. 1 to 7) + Diabetic Strategy if the patient has diabetes.

**Fig. 2.** Decision making tree for blood pressure class A patient on the highest level

**Theoretical basis.** Decision making in frame and production systems are different. In production system, forward inference is used. It (the facts – the conclusion) begins with the available facts about the problem. Applying the production rules, these facts are examined and new information is obtained. This is continued until the goal is reached [1] [2] [3]. Figure 3 shows how the management cycle recognize-act in the system works.

**Fig. 3.** Management cycle recognize-act

Having entered the patient data, they are placed in the working memory. The system considers the KB of production rules, starting with the lowest levels, and compares rule premises provided in the working memory. If these conditions are the same, the performance or conclusion of found rule is placed in the working memory. In the same way the system operates on the middle and highest level. When the system reaches the highest level, and finds the rule,
corresponding the premises of the working memory condition, the conclusion of this rule determinates AH strategies and system completes the search [3].

In the frame system, the decision is made calculating the rate of compliance for each frame:

\[ F = \frac{F_k^+ + F_k^-}{2} \],

(1)

\( F_k^- \) is a frame score for patient \( P_1 \);

\[ F_k = \frac{N_{P_i}}{N_{F_k}} \],

(2)

where \( N_{P_i} \) is the patient \( P_i \) symptoms, which coincides with the frame \( F_k \) symptoms; \( N_{F_k} \) is the number of symptoms, which consists of \( k \)-frame; \( F_k^- \) is \( k \)-frame rate liabilities over the total situation.

\[ F_k = \frac{N_{F_k^-}}{N_{F_k}} \],

(3)

where \( N_{F_k} \) is the frame comprising the number of symptoms, \( N_{F_k} \) is total number of symptoms of all participating frames. In this case, it is quite small, so it will not be taken into account, and compliance will be estimated only after \( F_k \) [4].

Results. Two ES are designed to determinate the AH patients risk and to recommend appropriate control strategy. Systems make decision according to entered parameters. Rule based system data input and conclusion is depicted in figure 4, 5 and 6, but for the frames based system in figures 7 and 8.

![Data input window of rules based system](image)

**Fig. 4.** Data input window of rules based system
Fig. 5. Data input window of rules based system

Fig. 6. Data result window of rules based system

Fig. 7. Frame based expert system (data input windows)
Fig. 8. Frame based expert system (data result windows)

The comparison of the developed ES is demonstrated in Table 1.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rule system</th>
<th>Frame system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Possibility of the knowledge representation</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>Amount of knowledge</td>
<td>88 production rules</td>
<td>127 frames</td>
</tr>
<tr>
<td>Logical sets</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of difficulty to design KB</td>
<td>easy</td>
<td>difficult</td>
</tr>
<tr>
<td>KB structures visibility for expert system</td>
<td>Depends on amount of knowledge</td>
<td>Clear</td>
</tr>
<tr>
<td>KB realization</td>
<td>KB representation is similar in all systems</td>
<td>Depends on chosen programming language</td>
</tr>
<tr>
<td>Resource of computer</td>
<td>Delphi</td>
<td>Flex, Prolog</td>
</tr>
<tr>
<td></td>
<td>88 production rules</td>
<td>125 frames</td>
</tr>
<tr>
<td></td>
<td>Independent file</td>
<td>Can not create independent file</td>
</tr>
<tr>
<td>The necessary human resources</td>
<td>The same in theoretical and practical part</td>
<td>Additional activities</td>
</tr>
<tr>
<td>Systems convenience for user</td>
<td>Easy to use</td>
<td>Less convenient for use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Require the Flex installation</td>
</tr>
<tr>
<td>System decision making</td>
<td>If…. Then… Forward inference</td>
<td>The formula for calculating the frame rate of compliance</td>
</tr>
<tr>
<td>Eligibility for particular task (AH strategy detection)</td>
<td>More appropriate for dynamic decision making</td>
<td>More appropriate for statistical aspect</td>
</tr>
</tbody>
</table>

**Conclusion.** Knowledge presented in „New European Hypertension Guidelines, 2003” can be formalized using both the production rules and frames. The comparison of the 2 types KB finds the production rule KB base to be easier to make and to use. The KB created allow to develop ES serving a definite aim, i.a., strategy selection for AH patients control.
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The paper deals with the building of knowledge bases on the existing knowledge amount in a given domain. In our case we operate with new European Hypertension Guidelines, 2003. There are developed two knowledge bases containing one and the same knowledge amount applying different representation techniques, i.e., rules and frames. Those knowledge bases are the central element of the two datorized systems for carrying out decision making on health care strategy of arterial hypertension patients. It makes possible the comparison and estimation of two knowledge bases and datorized systems on the whole.