How can we Benefit from Application of Intelligent Systems in Cardiology

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Abstract

In this paper we present the role of the physician in developing and using intelligent systems and benefits from using intelligent systems on cardiovascular database. As in many other areas, predictions play an important role in health care. What will be the status of the patient after the selected treatment, will the healing process end with the success or not are just some of the possible predictive questions faced by both patients and medical staff. Statistics can be of great help in many real world situations, but sometimes its use is limited. As an alternative we can use so called intelligent data analysis techniques like neural networks, case based reasoning, logic programming, or decision trees. The greatest weakness of the majority of these techniques is that they are black box approaches – normally giving good predictions but without explanation. One of the techniques overcoming this fault is the decision tree approach, which in addition to immense prediction power also explains the decisions leading to the predictions using a simple two dimensional graphical model.

We used the decision tree approach in the intelligent analysis of cardiac diseases in the young. We got excellent results, where some new diagnostic rules and guidelines have been extracted.

Keywords - intelligent systems, decision making, cardiology, cardiovascular.

Introduction

Many real-world medical problems are nowadays being handled with tools for automatic intelligent data analysis. Various methods such as neural networks, decision trees, genetic algorithms and hybrid systems have been developed and already evaluated on different medical databases. But from physician's point of view the ability to track and evaluate every step in the decision making process is the most important factor for trusting the decisions gained with machine learning methods. Therefore the role of decision trees in medical decision support is very important since they provide a very powerful feature – the possibility of explaining the decision in an easy and human understandable way. Just a brief look at the decision tree's structure can reveal a physician which attributes are the most important for the diagnosing, outcome prediction and similar. A more exact decision tree analysis can expose new relations, set new hypothesis, new facts thus enriching the medical knowledge.

In this paper we focus on inducing user-friendly intelligent systems, which would extract some important factors about emergency care of heart attack patients and thus help the physicians in improving the survival rate. That is very important since heart attacks are the leading cause of death in most of the highly developed countries.

Intelligent Systems

Similar to mechanical systems that increase our physical abilities (cranes to lift vast amounts, telescopes to see distant objects, etc.), intelligent systems are power tools for heavy lifting in the information world - they complement, extend, and amplify our ability to think and solve problems. The difference between intelligent systems referenced here and more usual expert systems or knowledge-based systems is that the intelligent systems are not necessarily smarter than expert or knowledge-based systems in terms of the quantity or types of knowledge or reasoning they employ; in fact, the research and application challenges are largely the same. However, the intelligent systems for the most part exploit additional tools and technologies that make them easier to use, easier to build and maintain, and easier to integrate with conventional information systems.

Longitudinal, multinational and multiview studies generates huge amount of data, which normally can not be effectively analyzed without automated methods. Intelligent systems can be used as an appropriate approach to dealing with these matters and have recently gained a lot of attention also in medical fields. They enable us to automatically analyse complex and huge data or knowledge bases and extract new knowledge related to diagnosing, prediction, classification, hidden relation, etc. The additional challenges of intelligent systems in the medical field are to present the results of these processes to medical staff in a simple human understandable form.
The latter is also the main reason why we decided to use decision trees, which are well known for their transparent knowledge representation.

Decision Trees

Inductive inference is the process of moving from concrete examples to general models, where the goal is to learn how to classify (predict) objects by analysing a set of instances (already solved cases) whose classes (predictions) are known. Instances are typically represented as attribute-value vectors. Learning input consists of a set of such vectors, each belonging to a known class (prediction), and the output consists of a mapping from attribute values to classes (predictions). This mapping should accurately classify/predict both the given instances and other unseen instances.
A decision tree [1, 2] is a formalism for expressing mappings from attribute values to classes (predictions) and consists of tests or attribute nodes linked to two or more subtrees and leafs or decision nodes labelled with a class which represents the decision. Because of the very simple representation of accumulated knowledge they also give us the explanation of the decision, and that is essential in medical applications.
The tool we used is called MtDeciT3.0, which added a few new features to the previous version [3, 4]. One of features is called improved dynamic discretization of continuous attributes, which was used in our experiments with success.

Cardiovascular Data Set

Cardiovascular disease is a prime cause of death in people under the age of 24; the second leading cause in the 0 to 14 years age group and the third leading cause in the 15 to 24 years age group is cardiovascular disease.
Some heart problems experienced by children, such as most cases of congenital (present at birth) heart defects, can be treated medically or surgically, but cannot be prevented. However, heart-healthy living habits started at an early age - sensible eat-ing, keeping cholesterol levels low, getting regular exercise, refraining from smoking, and maintaining a healthy weight - greatly diminish the risks of other cardiovascular problems such as stroke, high blood pressure, and coronary artery disease developing in adulthood. Thereafter the early and accurate identification of cardiovascular problems in children patients is of vital importance [5, 6, 7].
Pediatric records of 100 young patients from Maribor Hospital containing general data (age, sex, etc.), a health status (data from family history and child's previous illnesses), a general cardiovascular data (blood pressure, pulse, chest pain, etc.) and more specialized cardiovascular data – data from child's cardiac history and clinical examinations (with findings of ultrasound, ECG, etc.). Each of the patients was diagnosed with one of the following diagnoses: innocent heart murmur, congenital heart disease, palpitations with chest pain.

Results

The intelligent analysis of cardiac diseases in children was performed with decision tree induction approach. The results were discussed and evaluated by paediatricians.

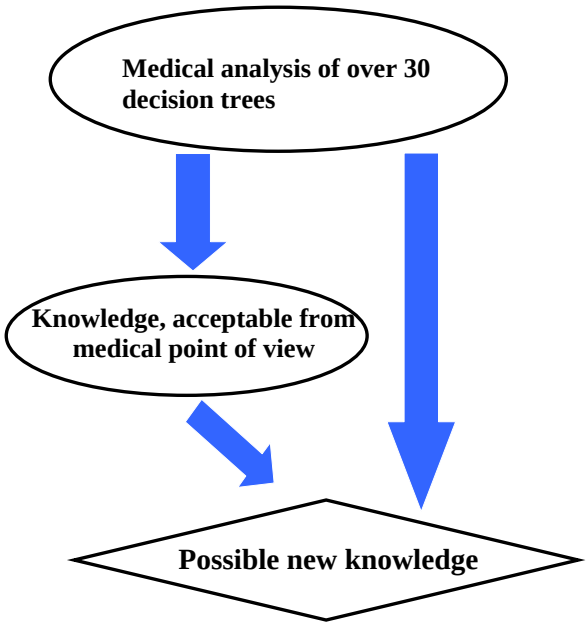

Figure 1: Process of analysis of generated decision trees

The paths through the induced decision trees (see sample in figure 2) have revealed many logical rules, which are all acceptable from the medical point of view and therefore show the quality of the decision trees but no new knowledge:

- The occurrence of other congenital malformations is related to an extended risk of joined congenital heart disease. We can clinically evaluate this congenital heart disease in children independent of their age.
- It is also well known that recurrent tonsillitis can lead to the damage of heart valves or myocardium. This damage can also lead to the clinical appearance of heart murmur or to heart arrhythmias.
- The system has discovered a close relation between convulsions in children and a possible difficult aortic valve disease.
- It has also been revealed that there is a connection between fever illness in children and a possible innocent heart murmur due to tachycardia.
- Furthermore, few rules in induced decision tree also represent possible new knowledge (new knowledge for the experts co-operating in the study/ very few or no references have been found in MEDLINE):
- A close relation between the history of children's operations under general anaesthesia and the appearance of different heart arrhythmias was discovered. It is well known that such arrhythmias can appear during the act of surgery. The system, however, has discovered that surgery can also be an important cause of arrhythmias occurring later in a child's life.

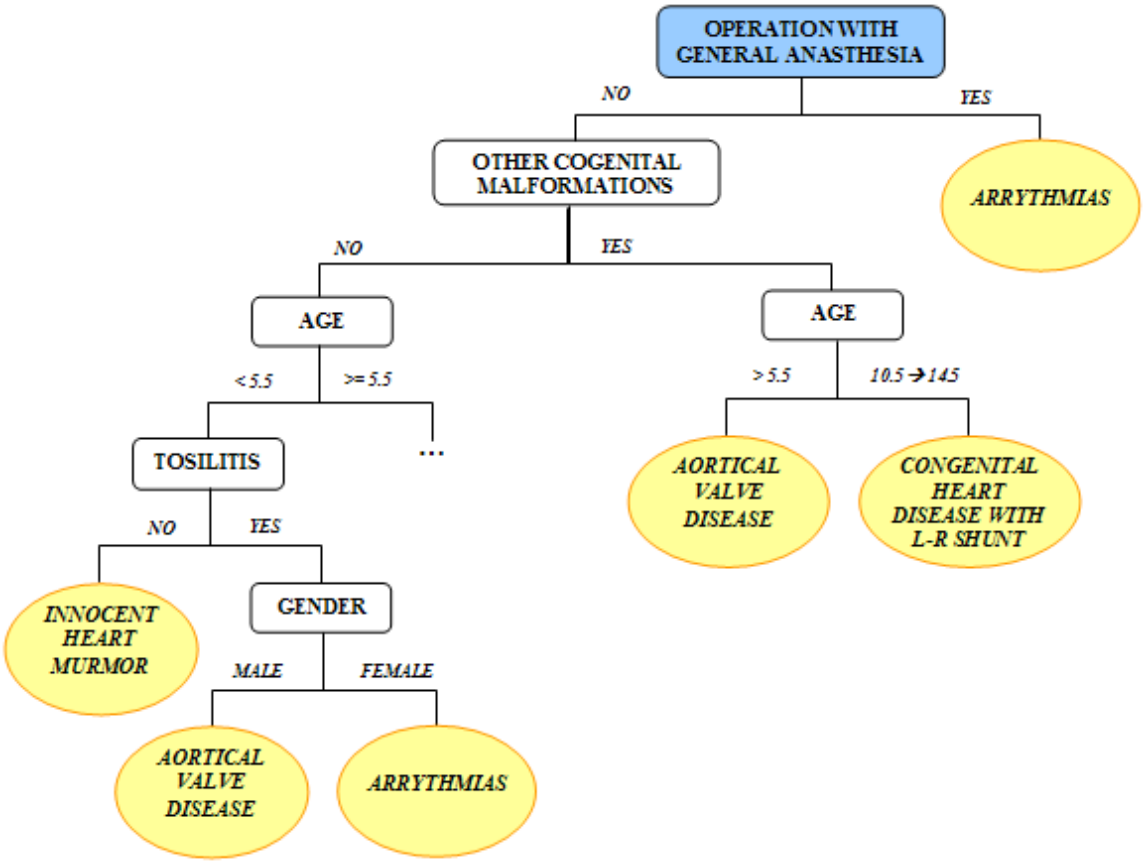

Figure 2: A part of a decision tree with new knowledge

Discussion

After evaluation of decision trees, the paediatricians classified the rules extracted from decision trees in the following groups (see table 1 and table 2):

- medically acceptable knowledge,
- known medical facts,
- possible new knowledge.

Table 1 Discovered knowledge

Medically acceptable knowledge	Possible new knowledge
A connection between fever illness in children and a possible innocent heart murmur due to tachycardia	Higher probability of appearance of different heart arrhythmias in cases of children with history of operations under general anaesthesia.
A close relation between convulsions in children and a possible difficult aortic valve disease	
Recurrent tonsillitis can lead to the damage of heart valves or myocardium	Correlation between convulsions in children and a possible difficult aortic valve disease
Occurrence of other congenital malformations is related to an extended risk of joined congenital heart disease	

Table 2 Interesting knowledge

Known medical facts	Possible new knowledge
Occurrence of arrhythmias during operations under general anaesthesia.	More often arrhythmias occurring months after child's operations under general anaesthesia!

With a great pleasure and scientific coincidence we can now make an assertion that the finding stated in the previous sections and above tables have been confirmed in a large EU study which results were presented by prof. Maria C. Seghaye et.al. at the medical conference in Porto [10].

Conclusions

In this paper we presented the role of the physician in developing and using intelligent systems and benefits from using intelligent systems on cardiovascular database. With our results we have shown that with help of intelligent systems, or more specific, decision trees analysis we can expose new relations, set new hypothesis, new facts thus enriching the medical knowledge.
We used the decision tree approach in the intelligent analysis of cardiac diseases in the young. We got excellent results, where some new diagnostic rules and guidelines have been extracted. The findings we extracted from decision trees, that were built using a database collected in the General hospital Maribor, were also confirmed in an independent study.

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