UNCERTAINTY AND IMPRECISION IN MEDICAL DIAGNOSIS SUPPORT

Medical diagnosis is a very complex task in which different kinds of information must be combined: answers from an interview, results of a primary investigation, outcomes of laboratory tests, images, parameters of electrical signals, etc. These observations are usually imprecise, e.g. patients’ answers are ambiguous and medical reports include linguistic description of examination results. The diagnosis is even harder if some test results are indistinct and few examinations are impossible to perform, for instance because of the patient’s state. Moreover, relations among symptoms and diseases are uncertain, since the same symptoms may occur with different diseases and one disease may have various manifestations. It might be concluded that an assessment of diagnostic evidence is difficult and requires considering two concepts: imprecision and uncertainty. This is a real challenge. Although researchers work on diagnosis support for many years, they manage to present only partly satisfactory solutions.

The first methods of inferring diagnoses from symptoms were based on statistics. Yet, conditions of a statistic research are very strict and often impossible to sustain. Results of the research usually cannot be transferred to another population, too. Nevertheless, statistics are roots of so-called medical indices (e.g. Crooks’ or Murray’s index) and guidelines that are commonly used in practice. Unfortunately, computerization of indices is worthless for diagnosis support because it is very difficult to introduce a new symptom to them or to change an evaluation of a medical procedure.

In the late 70s and 80s of the 20th century people were impressed by medical expert systems like MYCIN or CASNET. However, achievements of their creators can hardly be used in other diagnosis support tools, since they employ probability values that are difficult to obtain and have to be re-calculated for different populations and procedures.

Tools of the computational intelligence are also used to support the diagnosis. Neural networks and genetic algorithms are successfully used in oncology, critical care and cardiovascular medicine. Yet, these methods are oriented for pattern recognition and signal analysis and they barely combine information, particularly linguistic. They cannot replace knowledge-based systems that make use of expert’s experience and represent human-like inference. Furthermore, these methods lack explaining results, which is usually not acceptable for diagnosticians. Alternative tools for diagnosis support are systems that implement clustering, Bayesian networks or fuzzy inference. Particularly the latter are used with success in some medical units. Yet, researchers still struggle for a cheap and convenient tool of diagnosis support.

A method that can create a framework to match observation with knowledge and to indicate a diagnostic conclusion regarding its uncertainty and imprecision can be the Dempster-Shafer theory extended for fuzzy focal elements.

In the Dempster-Shafer theory focal elements are defined as predicates with assigned evidence. The evidence is represented by the basic probability assignment. Values of this assignment do not depend on relations among focal elements, so difficulties in calculation of the conditional probability, which occur in the classical probability theory, are avoided. The focal element may represent one or several symptoms. Each of them can be described by the measure of imprecision – for instance a membership function of a fuzzy set. The focal element is the premise of the rule which weight is the value of the basic probability assignment. Hence, semantically important differentiation between uncertainty and imprecision is preserved. Rule premises and patient’s symptoms are matched during the diagnosis. The more premises are matched, the more certain is the diagnosis. The better is matching the more precise is the diagnosis. The final conclusion is found after a comparison of belief measures of considered hypotheses. This method of diagnosis support was tested for benchmark and individually gathered databases. Obtained results are better than for reference methods, thus the method seems to be promising in solving various tasks of diagnosis support.