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Application of a Computer-based Diagnostic Tool to Training General Practitioners

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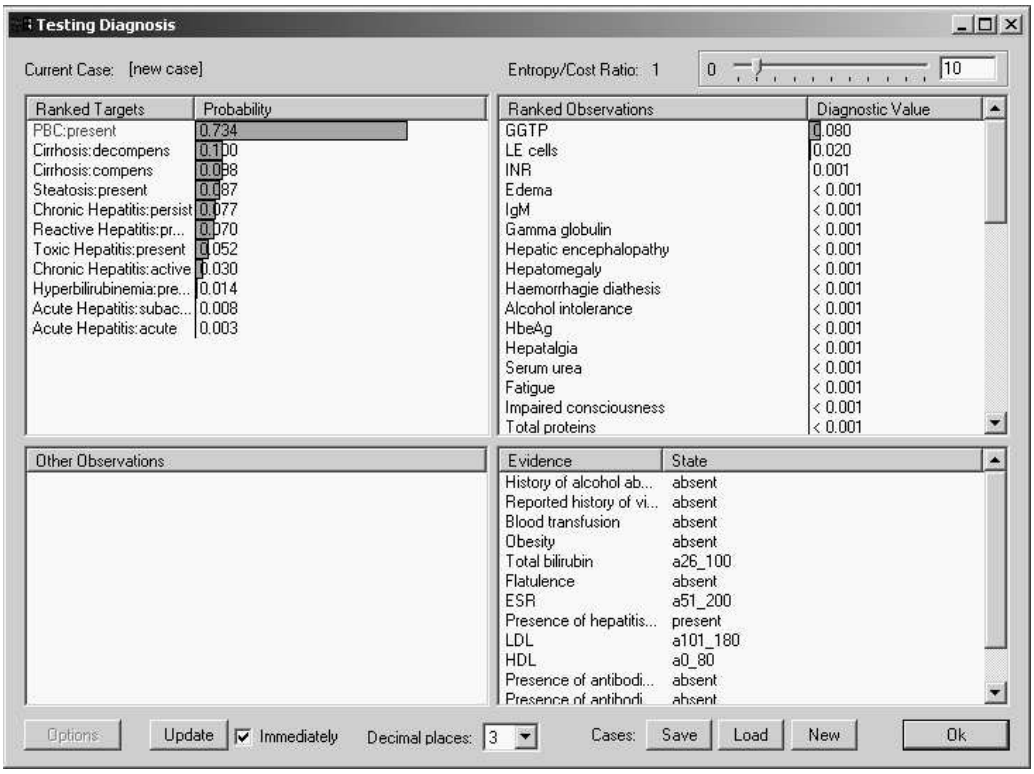
The last two decades have brought considerable advances in the field of computer-based medical systems. These advances have resulted in noticeable improvements in medical care, starting from ease of storage and access of digital imaging through gathering of computerized medical data, accessing on-line literature, patient monitoring, and therapy planning. Systems addressing the task of diagnosis, however, have rarely been adopted in clinical practice, which has raised questions about their usefulness and feasibility. We show in this paper a practical application of a computer-based diagnostic system, HEPAR II, to training beginning diagnosticians.

The HEPAR II system

Our work is a continuation of the HEPAR project [1, 6], conducted in collaboration between the Institute of Biocybernetics and Biomedical Engineering of the Polish Academy of Sciences and the Medical Center of Postgraduate Education in Warsaw. The HEPAR system, at the Gastroentorogical Clinic of the Institute of Food and Feeding in Warsaw, allows for systematic collection and processing of clinical data of hepatological patients diagnosed and treated in the clinic. The system is equipped with a diagnostic module built around several statistical methods. An integral part of the HEPAR system is its database, created in 1990 and thoroughly maintained since then. The current database contains roughly 860 patient records with the ultimate diagnosis verified by means of biopsy, laparoscopy, and often a longitudinal follow-up. Each hepatological case is described by over 150 different medical findings, such as patient self-reported data, results of physical examination, laboratory tests, and, finally, a histopathologically verified diagnosis.

The HEPAR II system, a continuation of the HEPAR project, applies decision-theoretic methods to the same problem. It is based on a Bayesian network model [5] built on a combination of the HEPAR data set with expert knowledge. The network captures various disorders, risk factors, symptoms, and test results. Details of the design of the HEPAR II model can be found in [3, 4]. Given a patient case, i.e., values of some of the modeled variables, such as symptoms or the laboratory tests results, the HEPAR II system combines the case information and calculates the posterior probability distribution over the possible liver disorders. Subsequently, the system presents its user with a list of suggested diagnoses rank-ordered by their probability. We show HEPAR II's simple user interface below.



The right-hand side of the window contains a complete list of all possible symptoms and observations included in the model. The top right part of the window contains a list of those possible observations that have not yet been made along with an indication of their diagnostic value for the pursued disorder (PBC in this case). Those features that have been observed are brought over to the bottom part of the window. Right-clicking on any of the features brings up a pop-up menu that lists all possible values of the selected variable. By choosing one of these values, the user can enter a finding. The top left column presents an ordered list of the possible diagnoses along with their associated probabilities, the latter being presented graphically. The probabilities are updated immediately after entering each finding. Updating the probabilities and presenting a newly ordered list of possible disorders takes in the current version of the model a fraction of a second and is from the point of view of the user instantenous. Our interface allows further to save a patient case in a repository of cases and to return to it at a later time.

Can a system like HEPAR II be useful?

There are several reasons for high expectations from computer-aided diagnosis in the domain of hepatology. Firstly, the number of cases of liver disorders is on the rise. In Poland, the number of new acute and chronic hepatitis cases is roughly half a million per year. Secondly, correct diagnosis, especially in early stages of a disease, is difficult. There is variety of diseases that manifests with similar symptoms. Finally, early diagnosis is critical, as in some cases damage to the liver caused by an untreated disorder may be irreversible.

Typically, a patient suffering from symptoms suggestive of abdominal disorders seeks help at a primary health clinic. Primary care physicians face the daunting task of determining the source

of discomfort based on patient-reported data and physical examination, possibly enhanced with the results of basic medical tests. Correct diagnosis, under these circumstances, is difficult and accuracy can be low. Based on our observations, we estimate that at this stage only 40-60% of the cases are diagnosed correctly. This rather low diagnostic performance is caused by several etiophysiological and organizational factors. These include the nature of the liver, e.g., its high productive reserves that often make the abnormalities noticeable only when the disease reaches an advanced stage. Development of liver diseases is often slow and tracherous. Symptoms may be hardly noticeable. Liver disorders are influenced by environmental factors, such as alcohol intake, medications, and diet. There is still insufficient knowledge of immunological factors that cause certain pathologies of the liver. Undiagnosed or misdiagnosed viral hepatitis often leads to irreversible defects of the liver that may have bearing on the manifestation of the possible later disorders. Reliable diagnosis of a liver disorder can be often established only based on the results of liver biopsy. However, biopsy is an invasive examination that is performed only in specialized clinics and may not be available to primary care physicians, who are HEPAR II's targeted users. We believe that use of the system should lead to a significant improvement in the timeliness and quality of diagnosis.

Practical experiences

Our colleague physicians have welcomed the HEPAR II system as a useful interactive diagnostic and training tool. The diagnostic accuracy of the model seems to be reasonable and, for those disorders that are well represented in the database of patient cases, reaches almost 80%.

We introduced the HEPAR II system to participants of courses training family doctors at the Medical Center of Postgraduate Education in Warsaw. ("Family doctor" is a new specialty in Poland, created by the recent health reform. The participants of the courses were physicians, sometimes with considerable clinical experience.) Our intention was to teach the doctors diagnostic strategies by means of simulation. In a session with the system, a physician could assess or verify the diagnostic value of medical findings in a given situation involving differential diagnosis. A thorough training in differential diagnosis allows a physician to recognize and choose an optimal diagnostic strategy, which its practice comes down to ordering the right tests for the right patients. Selection of those laboratory tests that have the highest diagnostic value can help in reducing the costs of health care. It also has a positive social impact by increasing the accuracy of diagnosis and correctness of therapy.

We compared HEPAR II's accuracy to the accuracy of the practitioners on a small set of past clinical cases. The system's accuracy (70%) was higher than that of the physicians (33%). (The complete results of this study are reported in [3].) The reaction of the physicians to the system was very favorable and several of them said that the system had been very understandable and that they had learned a lot from it. We observed that working with the system had a beneficial effect on the users – the diagnostic accuracy of physicians increased significantly (from 33% to 65%) after they had seen HEPAR II answers. Additionally, there was no negative impact of the system on the users, i.e., none of the correct decisions made by the physicians were changed, even if the system provided an incorrect answer. It has led us to the conclusion that the system can be useful in training of physicians.

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The HEPAR II model was created and tested using **SMILE**©, an inference engine, and **GeNIe**, a development environment for reasoning in graphical probabilistic models, both developed at the Decision Systems Laboratory, University of Pittsburgh, and available at http://www.sis.pitt.edu/GeNIe.

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